REPORT OF THE

NATIONAL COMMISSION ON AGRICULTURE

1976

PART X

INPUTS

GOVERNMENT OF INDIA
MINISTRY OF AGRICULTURE AND IRRIGATION
NEW DELHI

सत्यमेव जयते

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PREFACE

The Report of the National Commission on Agriculture comprises 69 chapters in 15 parts. A complete list of chapters and parts is given in pages (iii) and (iv). The Terms of Reference of the Commission and its composition are given in Part I — Chapter 1 — Introduction.

This volume, entitled 'inputs', is Part X of the Report and is divided into the following five chapters:

47. Seeds
48. Fertilisers and Manures
49. Plant Protection Chemicals
50. Farm Power
51. Implements and Machinery

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REPORT OF THE NATIONAL COMMISSION ON AGRICULTURE

PART I—REVIEW AND PROGRESS

1. Introduction.
2. Historical Review.
3. Progress of Agricultural Development.
4. Some Economic Aspects.

PART II—POLICY AND STRATEGY

5. Agriculture in Economic Development.
6. Growth with Social Justice.
7. Policy and Strategy.
8. Centre-State Relations in Agricultural Development.
9. Nutrition.

PART III—DEMAND & SUPPLY

10. Demand Projections.
11. Supply Possibilities.
12. Export Possibilities and Import Substitution.

PART IV—CLIMATE AND AGRICULTURE

13. Climate and Agriculture.
14. Rainfall and Cropping Patterns.

PART V—RESOURCE DEVELOPMENT

15. Irrigation.
16. Command Area Development.
17. Land Reclamation and Development.
18. Soil and Moisture Conservation.
19. Electricity in Rural Development.

PART VI—CROP PRODUCTION, SERICULTURE AND APICULTURE

20. Reorientation of Cropping Systems
21. Foodgrain Crops.
22. Commercial Crops.
23. Horticultural Crops.
24. Plantation Crops.
25. Fodder Crops.
26. Sericulture.
27. Apiculture.

PART VII—ANIMAL HUSBANDRY

28. Cattle and Buffaloes.
29. Dairy Development.
30. Sheep and Goats.
31. Poultry.
32. Other Livestock

2—3 Deptt. of Agri/76

33. Mixed Farming.
34. Livestock Feeding.
35. Animal Health.
36. Meat Production and Animal Byproducts.

PART VIII—FISHERIES

37. Inland Fisheries and Aquaculture.
38. Marine Fisheries.
39. Crustacean Fisheries and their Utilisation.
40. Marketing of Fish and Fishery Products.

PART IX—FORESTRY

41. Forest Policy.
42. Production and Social Forestry.
43. Minor Forest Produce.
44. Forest Ecology and Wild Life Management.
45. Forest Protection and Law.
46. Forest Planning, Research and Education.

PART X—INPUTS

47. Seeds.
48. Fertilisers and Manures.
49. Plant Protection Chemicals.
50. Farm Power.
51. Implements and Machinery.

PART XI—RESEARCH, EDUCATION AND EXTENSION

52. Research.
53. Education.
54. Extension.

PART XII—SUPPORTING SERVICES AND INCENTIVES

55. Credit an Incentives.
56. Marketing, Transport and Storage.
57. Processing and Agro-Industries.

PART XIII—RURAL EMPLOYMENT AND SPECIAL AREA PROGRAMMES

58. Rural Employment.
59. Special Area Development Programmes.

PART XIV—PLANNING, STATISTICS AND ADMINISTRATION

60. Planning.
61. Statistics.
62. Administration.
63. Farmers' Organisation.
64. International Cooperation.

PART XV—AGRARIAN REFORMS

65. Land Reforms Policy.
66. Land Reforms Legislation and Implementation.
67. Agrarian Structure and Perspective.
68. Consolidation of Holdings.
69. Agricultural Labour.

PART X

INPUTS

CONTENTS

CHAPTER 47—SEEDS	PAGE
SECTION	
1 INTRODUCTION	1
2 REVIEW	3
3 MEASURES TO MAKE SEED BUSINESS ATTRACTIVE	10
Seed Crop Insurance	10
Remissions	11
Discontinuance of Detrimental Practices	11
Processing, Packaging and Storage	12
Processing	
Packaging	
Storage	
Transport	15
4 MEASURES FOR QUALITY IMPROVEMENT	16
Provision of Grow-out Tests in Seed Testing Laboratories	17
Compulsory Certification of Hybrids and Seed Material of Vegetatively Propagated Crops	18
Indication of Minimum Renewal Period in Certificates	19
5 SEED RESEARCH, EDUCATION, TRAINING AND ORGANISATION	20
Sugarcane	22
Fodder Crops	22
Horticultural Crops	23
Research and Education	27
Organisational Set up	27
6 SUMMARY OF RECOMMENDATIONS	28
APPENDIX	
47·1 Magnitude of Seed Industry	35
Statement I—Basic Data for Calculating Area and Production Pertaining to Seed Crops as in 2000 AD	41
Statement II—Area and Production of Seed Crops as in 2000 AD	43
Statement III—Basic Data for Calculating Area and Production Pertaining to Seed Crop as in 1985	44
Statement IV—Area and Production of Seed Crops in 1985	46
CHAPTER 48—FERTILISERS AND MANURES	
SECTION	
1 ROLE OF FERTILISERS IN CROP PRODUCTION	47
Introduction	47
Fertiliser Consumption	47
Enhanced Foodgrain Production per Unit Area	50
Increasing Pressure on Land	50

Section		Page
2	PLANT NUTRIENTS	54
	Removal of Nutrients from Soils by Crops	54
	Natural Recuperation	55
	Fertilisers in the Farming System	57
	Need for Nutrient Balance	58
3	ASSESSMENT OF FERTILISER REQUIREMENT	61
	Methodology	61
	Consumption Trend in Fertilisers	71
	Extensive vs. Intensive Use	78
	Consumption Target	79
4	FACTORS AFFECTING EFFICIENT USE OF FERTILISERS	79
	Nitrogenous Fertilisers	82
	Anhydrous Ammonia	83
	Aqua Ammonia	84
	Slow Release Nitrogenous Fertilisers	85
	Phosphatic Fertilisers	85
	Potassic Fertilisers	87
	Micronutrients	88
	Application of Fertilisers	88
5	SOIL ORGANIC MATTER AND ORGANIC MANURES	89
	Sources of Organic Matter	91
6	CHEMICAL FERTILISERS AND SOIL AMENDMENTS	94
	Availability of Fertilisers	94
	Raw Materials and Feedstock	95
	Nitrogen	95
	Phosphorus	96
	Potassium	99
	Fertiliser Analysis	100
	Classification of Fertilisers	101
	Physical Condition of Fertilisers	102
	Fertiliser Grades	103
	Quality Control and Legislation	103
	Mixed Fertilisers	106
	Soil Amendments	107
7	FERTILISER DOSE	119
	Economics of Fertiliser Use	110
8	SOIL TESTING AS A GUIDE TO EFFICIENT USE OF FERTILISERS	114
	Present Status of Soil Testing	115
	Evaluation of Soil Test Work	120
	Soil Test—Crop Response Correlation	121
	Soil Fertility Maps	124
9	SUMMARY OF RECOMMENDATIONS	125
	Plant Nutrients	125
	Factors Affecting Efficient Use of Fertilisers	126
	Soil Organic Matter and Organic Manures	126
	Chemical Fertilisers and Soil Amendments	127
	Fertiliser Dose	128
	Soil Testing as a Guide to Efficient Use of Fertilisers	129

APPENDIX PAGE

48·1 Nutrients Removed by Foodgrain Crops—Actual and Projected Production 131
48·2 Nutrients Removed by Non-foodgrain Crops—Actual and Projected Production 132
48·3 Removal of Nutrients by Foodgrain and Non-foodgrain Crops—Actual and Projected Production 133
48·4 Cropwise Fertiliser Requirement 134
48·5 Fertiliser Requirement for Total Cropped Area Based on Doses Recommended Following Fertiliser Trials 135
48·6 Estimated Fertiliser Requirement by 1978-79 137
48·7 Production, Imports and Consumption of Chemical Fertilisers in India—1961-74 140
48·8 Estimates of Some of the Waste Products Available in the Country Annually 141
48·9 Pattern of Feed Stock Utilisation for Nitrogen Capacity (Installed and Planned) 142
48·10 Equivalent Acidity and Basicity of Different Fertiliser Materials 147
48·11 Number of Soil Testing Laboratories in India and Their Capacity 149

CHAPTER 49—PLANT PROTECTION CHEMICALS

SECTION

1 INTRODUCTION 151
2 ROLE OF CHEMICALS IN PEST CONTROL FOR ENHANCED CROP PRODUCTION 154
3 EXTENT OF CROP LOSS DUE TO INSECT PESTS AND DISEASES . 159
Guidelines for the Future 159
Serious and Moderate Insect Pest and Diseases . . . 161
4 EFFICIENCY OF CHEMICALS IN PEST CONTROL AND INCREASING CROPS PRODUCTION 163
Pest Resistant Varieties and Pesticide Use 164
Potentiality of Chemicals 165
Application Methods 166
5 CHEMECALS IN FARMING SYSTEM : SURVEILLANCE AND WARNING 166
Surveillance in the Indian Scene 167
General Plan 167
Main Findings 168
Plant Pests and Diseases Surveillance Service . . . 169
Method and Training 171
Quarantine Operations 172
6 ECONOMICS OF THE USE OF AGRICUTURAL CHEMICALS . . 173
Benefit-cost Ratio 174
Impact on Cultivators 176

SECTION | PAGE

7	ASSESSMENT OF REQUIREMENTS OF AGRICULTURAL CHEMICALS	177
	Requirement of Chemicals	186
8	BASIC RAW MATERIALS, KNOWHOW AND INDIGENOUS AVAILABILITY	190
	Chlorinated Hydrocarbons	190
	Organophosphates	191
	Carbamates	192
	Fungicides	193
	Weedicides	194
	Acaricides	195
	Nematicides	196
	Plant Growth Regulators	196
	Natural Sources of Pesticides	197
9	FERTILISER PESTICIDE MIXTURE	198
	Method and Time of Application	199
10	RESIDUAL TOXICITY AND HAZARDS OF PESTICIDES	200
	Pesticides and Soil Microorganisms	204
	Integrated Pest Control	205
	Storage Pesticides	206
11	QUALITY CONTOL OF PESTICIDES	207
	Complaints about Quality	207
	Factros Determining Quality Deterioration	208
	Arrangements for Pesticide Analysis	209
	Methods of Sampling and Analysis	211
	Rapid Testing	212
	Adequacy of the Insecticide Act	212
	Testing and Certifying Authorities	213
	Extension Education on Quality	213
	Central Pesticide Release Committee	214
12	PLANT PROTECTION SERVICES	215
	Timely Supply	218
	Sale Points	219
	Storage	219
	Custom Service	220
	Subsidy	220
	Promotional Work	221
	Plant Protection Organisations	222
	Setup in States	222
13	SUMMARY OF RECOMMENDATIONS	223
APPENDIX		
49·1	Questionnaire	229
49·2	Some Records of Felt Loss Due to Diseases in India	233
49·3	Some Records of Felt Loss Due to Insect Pests in India	237
49·4	Some Records of Felt Loss and Loss Estimation Due to Nematodes in India	239
49·5	Some Loss Estimations Due to Diseases Carried Out in India	240
49·6	Some Loss Estimation Due to Insect Pests Carried Out in India	243

APPENDIX		PAGE
49·7	Some Loss Estimation Due to Weeds Carried Out in India .	245
49·8	I—Some Loss Estimations Due to Rats under Field Conditions Carried Out in India	248
	II—Damage Caused by Rodents to Various Foodgrains Under Field Conditions in Uttar Pradesh	249
49·9	Cropwise Average Yields and Percentage Losses Due to Insect Pests and Diseases of High Yielding Varieties during Kharif 1967 and 1968	250
49·10	Cropwise Average Yields And Percentage Losses Due to Insect Pests and Diseases of High Yielding Varieties During Rabi, 1967-68 and 1968-69	252
49·11	Percentage Loss in Yield Due to Different Insect Pests and Disseases	253
49·12	Cropwise Losses Due to Insect Pests And Diseases as Reported by States	255
49·13	I—Serious and Moderate Insect Pests of Paddy Crop . .	256
	II—Serious and Moderate Diseases of Paddy Crop . .	257
49·14	I—Serious and Moderate Insect Pests of Jowar, Maize, Bajra and Lesser Millets Crops	258
	II—Serious and Moderate Diseases of Jowar, Maize, Bajra and Lesser Millets Crops	259
49·15	I—Serious and Moderate Insect Pests of Wheat, Barley and Oats Crops	260
	II—Serious and Moderate Diseases of Wheat, Barley and Oat Crops	261
49·16	I—Serious and Moderate Insect Pests of Cotton Crop . .	262
	II—Serious and Moderate Diseases of Cotton Crop . .	263
49·17	I—Serious and Moderate Insect Pests of Jute and Sugarcane Crops	264
	II—Serious and Moderate Diseases of Jute and Sugarcane Crops	265
49·18	I—Serious and Moderate Insect Pests of Pulses (Black and Green Gram, Gram, Pigeon Pea, Pea)	266
	II—Serious and Moderate Diseases of Pulses (Black and Green Gram, Gram, Pigeon Pea, Pea)	267
49·19	I—Serious and Moderate Insect Pests of Oilseeds (Groundnut, Mustard, Castor, Til, Linseed)	268
	II—Serious and Moderate Diseases of Oilseeds (Groundnut, Mustard, Castor, Til, Linseed)	269
49·20	I—Serious and Moderate Insect Pests of Plantation Crops .	270
	II—Serious and Moderate Diseases of Plantation Crops .	271
49·21	I—Serious and Moderate Insect Pests of Tobacco, Pepper, Turmeric, Ginger, Cumin, Coriander, Cardamom and Chilli Crops	272
	II—Serious and Moderate Diseases of Tobacco, Pepper, Turmeric, Ginger, Cumin, Coriander, Cardamom and Chilli Crops	273

Appendix		Page
49·22 (a & b)	I—Serious and Moderate Insect Pests of Mango, Apple, Banana, Grapes and Citrus Crops	274
	II—Serious and Moderate Diseases of Mango, Apple, Banana, Grapes and Citrus Crops	276
49·23 (a, b & c)	I—Serious and Moderate Insect Pests of Vegetable Crops	277
	II—Serious and Moderate Diseases of Vegetable Crops	280
49·24	Abbreviations Used for Insect Pests and Diseases	281
49·25	Maximum Protection Trial For Chemical Control of Insects	286
	I—Incidence of Neck Infection and Yield of Rice in Blast Control Trial with Foliar Sprays of Fungicides, Kharif, 1969	289
	II—Effect of Fungicides and Antibiotic on Control of Blast Diseases of Rice (Variety ADT 27)	290
49·26	I—Effect of Fungicides in Controlling Rusts of Wheat (Variety S227)	291
	II—Effect of Fungicides on Control of Rust (1965-66) of Wheat Variety Agra Local)	292
	III—Effect of Fungicides on the Control of Wheat Rust, 1966-67	293
	IV—Effect of Fungicides in Controlling *Alternaria* Leaf Blight of Wheat (Variety K 25)	294
	V—Effect of Fungicides on Control of Leaf Blight of Wheat (Variety Kenphad 25)	295
49·27	Variation in the Use of Chemicals and Their Dosages for Rice Crop	296
49·28	Benefit-Cost Ratio with Chemical Plant Protection Measures in Different Crops	300
49·29	Bene fit-Cost Ratio of Chemicals Used for Plant Protection	304
49·30	Categorywise and Cropwise Breakup of 100 Million Hectares—Level to be Reached by 1978-79	305
49·31	Summary of Information obtained on the Requirement of Chemicals by States	307
49·32	Summary of Information obtained on the Basis of which Annual Targets for Chemicals and Evaluation of Achievements made by States	308
49·33	Estimated Requirement of Pesticides Cropwise by 1978-79	310
49·34	Raw Materials for 1000 Kg. of Insecticides	316
49·35	Classification of Chemicals Based on Physical Condition and Grades	319
49·36	Names of Plant Protection Chemicals	326

CHAPTER 50—FARM POWER

Section		
1	Introduction	340
2	Farm Power and Productivity	341
	Source of Farm Power in Different Countries	341

Section		Page
	Indian Farm Power Spectrum	342
	Crop Yields and Power	345
3	REQUIREMENTS OF FARM POWER	346
	District Level Studies	346
	Draught Animals	347
	Human Labour	348
	Need for Selective Mechanisation	348
	Non-Repetitive Needs	350
	Tractor Needs in Crop Production	351
	Pumps for Irrigation	352
	Electrical Motors for Other Purposes	353
	Plant Protection Equipment	354
	Harvesting and Threshing Combines	354
	Power Position in 2000 AD	355
4	MANUFACTURE, QUALITY CONTROL, SUPPLY AND SERVICES	356
	Production Capacity	357
	Testing and Quality Control	358
	Sale and Service	359
	Agro-Industries in Supply and Services	360
	Future Role of Agro-Industries Corporations	364
5	ORGANISATION, EDUCATION AND RESEARCH	366
	Manpower Requirements	366
	Education and Training	367
	Research	370
6	SUMMARY OF RECOMMENDATIONS	371
APPENDIX		
50·1	Horse Power Equivalents of Various Power Components as Collected from Certain Sources	375
50·2	Existing Power Availability	377
	Statement I—Power for Agricultural Operations Available in 1971	377
	Statement II—Number of Districts (Statewise) in dfferent Ranges of Horse Power Representing the Total Animate (Human and Draught Animals) and Inanimate Power Available for Crop Production	378
	Statement III—Number of Districts (Statewise) in Different Ranges of Horse Power Representing the Inanimate Power (Electrical and Mechanical) Available for Crop Production	379
50·3	Power Needs	380
	Statement I—Monthly Power Needs for Crop Production in Hissar and Karnal Districts of Haryana (if these are to be met fully from Biological Sources)	380
	Statement II—Monthly Power Needs for Crop Production in Bijapur and Kolar Districts of Karnataka (if these are to be met fully from Biological Sources)	381

3—3 Deptt. of Agri/76

APPENDIX PAGE

Statement III—Monthly Power Needs for Crop Production in Burdwan District of West Bengal (if these are to be met from Biological Sources) . 382

50·4 Requirements of Agricultural Tractors for Crop Production in 2000 AD 383

50·5 Maps . . . .

Map I—Total Availability of Power from Animate and Inanimates sources (HP/ha) . . . . . Facing 386

Map II—Mechanical and Electrical Power Availability (HP/ha) . . . . Facing 386

CHAPTER 51—FARM IMPLEMENTS AND MACHINERY

SECTION

1 INTRODUCTION 386

2 HAND OPERATED AND ANIMAL DRAWN IMPLEMENTS AND MACHINERY 393

Tillage Implements 394

Ploughs 395

Seed Bed Preparation Implements 397

Harrows 397

Clod Crushers 398

Levellers 399

Tillage Implements in General 399

Seeding Implements 400

Weeding and Inter-cultivation 403

Harvesters, Threshers and Winnowers 404

Devices for Lifting Water 406

Miscellaneous Appliances and Hand Tools 407

General Improvements 408

Bullock Carts 410

3 INANIMATE POWER OPERATED IMPLEMENTS AND MACHINERY 411

4 MANUFACTURE, QUALITY CONTROL, SUPPLY AND SERVICE . 415

Quality Control 416

Need for Market Surveys and Demand Studies 417

Supply and Service 418

Employment Opportunities 418

5 SUMMARY OF RECOMMENDATIONS 419

APPENDIX

51.1 Map—Certain Selected Indigenous Agricultural Implements . Facing 426

51.2 Terms of Reference and Recommendations—Report of the Panel of Agricultural implements 423

51.3 Chart—Diagrams of Certain Selected Implements . . . Facing 426

51.4 Chart—Multipurpose Tool Bar . . . . Facing 426

47

SEEDS

The present chapter maintains continuity with the Seed Review Team Report (June, 1968) and the two Interim Reports of this Commission entitled (a) Multiplication and Distribution of Quality Seed pertaining to High Yielding Varieties and Hybrids of Cereals[1] and (b) Potato Seed. Although the first Interim Report dealt with cereal crops, certain principles were enunciated therein which have their applicability also to other crops in general.

1 INTRODUCTION

47.1.1 Seed production according to modern technology has gained ground within the country during the last two decades. The techniques of seed production involve proper land selection, maintenance of a specified isolation distance, rougeing, synchronisation of flowering in male and female lines (in hybrid seed production) and constant vigil in general. In addition, plant protection measures and prevention of moisture stress particularly during seed formation and development are also needed. The post-harvest requirements with regard to drying, processing, grading, seed treatment, packaging and storage are also exacting. In certain crops, there are some complicated procedures involved, which need very skilled handling. For example, it is necessary in maize hybrid seed production to detassel the female lines no sooner the tassel protrudes out of the flag leaf but before it sheds the pollen. This operation needs special care over a period of about 10 days till all the female plants are detasselled. In the case of cotton hybrids, the flower buds of female line require to be emasculated at an appropriate stage towards the evening and covered with butter paper bags to prevent cross pollination and drying of the stigma. The emasculated buds require to be pollinated the next morning using pollen of male parent. A differentiation has to be maintained between the

1 Hereafter referred to as Interim Report on multiplication and distribution of Seeds of Cereal Crops.

emasculated but not pollinated buds and the emasculated but pollinated ones. Despite these rigours, Indian farmers, who have participated in the programme of certified seed production, have proved that they can rise to the occasion and perform the needed operations quite skilfully. A sample survey conducted by the University of Agricultural Sciences, Bangalore showed that the seed producers followed even a more intensive package of practices than what was recommended. This should be an ample proof of the interest and capability of an average farmer of the country in regard to seed production. Seed production is undoubtedly a highly remunerative enterprise and it was only very recently that some of the seed producers of Varalakshmi cotton got around Rs. 250 per kg of the seed produced giving a gross income of about Rs. 2.5 lakhs per hectare. The remunerative nature of seed business indeed works as an attraction for farmers to participate more and more in this new venture.

47.1.2 Seed multiplication programmes thus far have been formulated and implemented with governmental initiative, efforts and organisation. For successful implementation the Governments have been organising the necessary publicity and promotional measures. They have been selecting and sponsoring the varieties. There has been no competition. The overhead expenditure being high in governmental enterprises, the cost of seed has been high and, therefore, the seed has to be subsidised directly or indirectly in various ways. The question for the future is whether a seed programme to cover the entire area of the country with good quality seed should be developed on commercial lines or on social welfare considerations. Suggestions have been made on many occasions that the Central and State Governments should take full responsibility for production and supply of quality seed at cheap rates. The Commission has examined this question in detail and is of the view that the social welfare approach in seed development with direct governmental involvement would commit the official machinery to an intricate task of a vast magnitude, which is not desirable. The programme should be developed on commercial lines so that it generates interest, a spirit of competition, a motive of profit and thus creates an employment potential for the educated as well as others. In this chapter, we propose to discuss how the seed programme could be developed in this manner.

47.1.3 The magnitude of seed production in 2000 A.D. in order to cater to a gross cropped area of 200 Mha covering all kinds of foodgrain, commercial, horticultural, plantation and fodder crops has been worked out in Appendix 47.1. It would mean an involvement of about 70 breeder seed institutions, a few foundation seed agencies at the national level and about 50 of them in States including official and private ones, 360 certified seed agencies, 12 million farmers, 12,000

artisans and 10,000 graduates. It would require about 3,150 seed processing units and an equal number of storages. In addition, one small storage at about 30,000 assembling and sub-market centres with an average distribution of one centre within every 5 km radius is essential in order to provide easy access to farmers in times of actual sowing operations. A task of this magnitude would mean addition of a distinctly new dimension to the already existing activities relating to crop production, through which a significant cross-section of cultivators stands to benefit. Besides fulfilling internal needs, the seed business can also be developed so as to cater to the needs of foreign countries. A wide variety of agro-climatic conditions obtainable within the country confers an advantage of producing seed of crops which thrive in temperate, subtropical and tropical latitudes or which flourish in different ranges of humidity and soil moisture. There is shortage of land in some countries. Also, due to industralization many countries have the constraint of costly agricultural labour and are not self-sufficient in their seed requirements. As against this, India has the advantage of vast land and there is no dearth of agricultural labour, which is much cheaper than in many other countries. These favourable factors can be utilized to expand the scope of the seed industry in due course. The prospects of employment would increase for many more people than what has been envisaged to begin with in Appendix 47.1. Even reputed foreign seed firms and scientists could be invited to collaborate in the programme of seed production for their countries, when it gets under way.

2 REVIEW

47.2.1 The earliest to engage attention in the country for seed production were vegetables, cotton and a few other crops. Whereas private industry got attracted in vegetable seed business, other crops depended upon governmental efforts. Although improved varieties were evolved as a result of research, their seed was not available in large quantities for use by farmers. The Royal Commission on Agriculture (RCA) (1928) had recognised this lacuna and had recommended setting aside separate staff in the State Departments of Agriculture to attend to seed testing and seed distribution. It was recomended that the cooperatives and seed merchants of proven integrity might also be involved. However, increased attention to seed production started only during the post-war period as a part of Grow More Food Campaign. The Famine Enquiry Commission (1945) and the Grow More Food Enquiry Committee (1952) noticed many shortcomings in the system and made certain recommendations for improvement. At-

4—3 Deptt. of Agri/76

tempts have since been made to set up a large number of seed farms during the plan periods essentially with a view to producing the required quantities of foundation seed of food crops. There is now a network of about 2,000 seed farms in the country. The programme of further multiplication envisaged involvement of progressive farmers as registered seed growers and of cooperative societies for storage and marketing. The departmental staff was to maintain check on the quality of seed at every stage. Even payment of bouns to seed growers and cooperatives was considered to serve as an impetus.

47.2.2 Although the programme helped to provide a structure and semblance of a systematic organisation, it broke down in implementation at the field level. The weaknesses of this programme have been brought out by the periodic review of the seed programme made by the Ministry of Agriculture and Irrigation and by the Programme Evaluation Organisation and the Seed Multiplication Team of the Committee on Plan Projects of the Planning Commission. Coordination in breeding programmes of States was more or less absent initially. It started developing later in the States in the form of Agricultural Research Conferences (AGRESCO) and between the States comparatively recently in the form of workshops for different crops held as a part of All-India Coordinated Research Projects. The sixties marked further development with the introduction of high yielding varieties and hybrids of cereals and better crop technology. New hybrids of maize were released as early as 1961 followed by the release of hybrids of jowar and bajra and high yielding varieties of paddy and wheat. This was all between the years 1961 and 1966. Farmers showed great inclination to accept these varieties and hybrids. This resulted in the development of the New Strategy, one of the main aspects of which is the High Yielding Varieties (HYV) programme.

47.2.3 It became necessary for the Central Government to think of means of multiplication and distribution of seeds of high yielding varieties as a concomitant of the HYV programme. The National Seeds Corporation (NSC) was started in 1963 to organise initially the production of small quantities of hybrid seed and the seed of some specific vegetables. In 1965, the NSC was given an expanded role of producing foundation seed and initiaing a programme of maintaining quality of seed. It organised a fairly good system of seed certification by about 1965 with the help of Indian Agricultural Research Institute, the Indian Council of Agricultural Research and the Rockfeller Foundation. It had to arrange also for production and marketing of certified seed. Its activities encompassed States and gradually the Blue Tag of NSC became a hallmark of quality seed in the country. Increasing emphasis on quality seed had necessitated the setting up of seed testing laboratories. The first Seed Testing Laboratory was

established in 1961 at the IARI. Thereafter a programme was undertaken to establish such laboratories in every State. A Central Seeds Act was passed by the Parliament in December, 1966. It, however, became operative in October 1969. This marked the beginning of a statutory provision for quality control of seed. To begin with, it made compulsory only the truthful labelling of seed material while certification of seed remained voluntary.

47.2.4 The maximum impact of HYV programme has been experienced only in the case of wheat, where the coverage has been around 45 per cent of the cropped area. Paddy comes next with about 20 per cent and the coverage under other cereals ranges between 4 and 15 per cent (1971-72). Progress in other crops is comparatively nominal, but even in the case of the area of cereal crops, it does not necessarily follow that the area once covered always gets seed of requisite quality in the succeeding years. Therefore, the coverage of the cropped area by the HYV programme is not the true yardstick for assessing the progress of seed multiplication work. It is a general complaint that quality seed of high yielding varieties is in short supply for the major cereals and not available at all for many of the other crops. Considerable difficulty has been experienced in vouchsafing the quality of seed, available through commercial channels. Consequently, the entire gamut of seed activity commencing from the release of varieties to their multiplication, quality control, processing, packaging, storage, distribution and transport were examined by the Seed Review Team (SRT) with the object of saturating the country's cropped area with improved seed of known quality. It considered mainly the 12 crops, viz., paddy, wheat, maize, sorghum, bajra, ragi barley, gram, groundnut, cotton, jute and tur, but references were also made to vegetables, potato, soyabean, forage crops and grasses. A concept of distinct wings for different activities is found implicit for the first time in its recommmendations, the wings being: (a) production and related activities upto distribution stage, (b) seed certification, and (c) seed law enforcement. The Team laid down very cryptically that seed certification agencies should be independent from the agency producing or selling the seeds on the one hand and the agency enforcing the Seeds Act on the other. Various training programmes in seed technology were also suggested.

47.2.5 Many problems arose in the implementation of SRT report by the time this Commission was set up. It was considered important by us to amplify or reinforce SRT's recommendations, more specifically with regard to cereal crops. In addition we felt that potato also deserved special attention because of its possible role in supplementing cereal diet. Consequently, the two Interim Reports on multiplication and distribution of seeds of cereal crops and potato

seed were brought out. The substantive part of the Interim Report on the multiplication and distribution of seed and cereal crops specifies the responsibilities of seed multiplication at different stages in order to induct as much of private interest into the business as possible and introduce market intelligence by way of governmental assessment of seed requirements for determining the targets of production of individual agencies. The Interim Report on potato seed is drawn on the main lines of the other. In addition, the importance of banning import of potato seed material from abroad and the need for imposing restrictions on internal movement from such areas which pose danger of spreading diseases and pests have also been stressed. Potato seed development councils have been contemplated for the Centre as well as the States in order to examine and regulate from time to time various kinds of programmes pertaining to multiplication and distribution of seed material.

47.2.6 According to the Interim Report on the multiplication and distribution of seeds of cereal crops, the responsibility of multiplying breeder seed is required to be entrusted to certain selected breeders and breeder institutions. This selection has to be done by the ICAR for Centrally controlled institutions and programmes and States in their own respective jurisdictions. It has also been explained that the ICAR could confine its role to the selection of institutions etc. as far as the all-India varieties are concerned, which are issued from the Central institutions and from the All-India coordinated research projects. Varieties of crops which relate to export and industrial production also need to be handled in a similar way. For all varieties issued from State institutions and universities, the States could nominate breeders. In the matter of multiplication of foundation seed, monopoly by any single agency has to be avoided. For this purpose, the NSC has to devote attention mainly to varieties of all-India importance, but it has to involve agricultural universities, State Farms Corporation and other institutions also in its production programmes. Multiplication of seed of local varieties could be the responsibility of the concerned State Governments, which have to nominate or create one or more institutional agencies for the purpose. This distinction between the jurisdiction of the ICAR and the States has been made in order to avoid chances of both fixing institutions for one and the same variety. Direct governmental involvement has to be avoided in the production and marketing of certified seed. The job has to be diversified and got done in various ways, e.g., through seed corporations, seed cooperatives, seed growers' organisations, agro-industries corporations and private agencies including individuals. Agro-industries corporations could ordinarily participate in marketing business only, but these could

also be utilised to enter into production programmes when governmental interests so necessitate. The basic principles laid down in the Interim Report on the multiplication of seed of cereal crops could be extended to other crops too.

47.2.7 In our discussions with leaders of the All-India Coordinated research Projects and others, we were asked to examine the role of the farms of the State Farms Corporation of India and the Seed multiplication farms of the States. There are about one dozen farms of the State Farms Corporation situated in various States. Their area generally ranges from 1000 ha to 12,000 ha. Their disadvantage is that these are very few in number and, therefore, cannot make any large scale contribution to the seed production programme. Their advantages are : (a) vastness and (b) situation in different climatic regions. These advantages are good for (a) compact-area production to suit requirements of isolation, (b) large scale prophylactic or curative crop production operations and (c) production which requires special considerations of climate. These farms can thus at best be of help in foundation seed production in special cases by mutual arrangements with the NSC. State foundation seed agencies or the State Governments. These farms cannot be involved in the production of breeder or certified seed, nor could they have any direct responsibility like that of any organised agency such as the NSC even in the production of foundation seed. Their role is collaborative only. Insofar as seed multiplication farms of the State Departments of Agriculture are concerned, their network is indeed widespread. There is ample scope for their utilisation by the Governments concerned in various special programmes. because of the magnitude and varied nature of multiplication work. However, these need not take part in the production of certified seed in general, because this has been chiefly left to private or quasi-governmental parties. The Interim Report on multiplication and distribution of seeds of Cereal Crops leaves enough initiative with the NSC and State Governments to utilize the state farms and seed multiplication farms as explained here.

47.2.8 It is contemplated in the Interim Report under reference that the ICAR could lay down procedures for prerelease trials of varieties. It has been our view that a variety should be recommended for general adoption only if it has secured success under field conditions in trials both at government farms as well as at a few selected farmers' holdings. Trials in farmers' fields presuppose making available the seed of new varieties to a select few and owing to this reason a question has often been raised as to why only some persons be put in an advantageous position. The unscrupulous amongst them can utilize the new stock and make profits. This defect occurred in the past, because varieties were entrusted only to a few individuals. It

can be rectified if a large number of farmers widely dispersed are made to participate in the programme. The Mini-Kit programme introduced in the pre-release trials of new paddy varieties satisfies this requirment in principle. If care is taken in practice to ensure that no one can exploit the situation to his advantage at the cost of farmers in general, it would fully meet our viewpoint. The other point which is important in regard to release of varieties relates to avoiding duplication of naming and uncoordinated releases. The desirability of having a 'National Registry' of varieties has long been advocated in this connection. The purpose of a national registry would be to ensure that the same variety is not given different names by different variety release committees and that a central place is used for properly maintaining a full description and other particulars related to varieties regardless of whether those have been released at the Central or State level. We should now like to emphasise the urgency and importance of having a National Register of Varieties.

47.2.9 The Central Government had constituted the Central Seed Committee (CSC) in September, 1968 in accordance with the Central Seeds Act (1966). The Act had envisaged that the CSC could appoint one or more subcommittees for discharging such of its functions as might be delegated by it to them from time to time. The CSC accordingly constituted individual Central subcommittees for variety release, crop standards and notification and seed testing and seed law enforcement. It also constituted State Seed subcommittees. A Central Variety Release Committee (CVRC) of the ICAR had been working between 1963 and 1970 for screening and releasing of new varieties for public use. There were the State variety release committees (SVRC) also. The former was mainly looking after the varieties released by the Centre, while its counterparts in the States were meant for the varieties evolved in their respective areas. With the taking over of the functions of release of new varieties by the CSC, the CVRC now does not function. Similarly, in many States, the State seed subcommittee is now performing the functions of the SVRC, but there are a few States where SVRC is still operating in addition to the State seed subcommittees. Such States have to wind up their SVRCs and fall in line with the usual pattern. The CSC with the assistance of its State sub-committees can operate a system of national registry of all the varieties whether released by the Centre or the States. A suitable registration fee can also be introduced for the purpose. The CSC can arranged to inspect the material at the farm of the applicant and for this purpose, it would be obligatory on the part of the applicant to grow the variety for registration as per required specifications. This procedure is necessary for enforcing a check in the distinctiveness of the variety in question. The ICAR has already prepared a proforma for description of

varieties, which could be conveniently used. Further rules and procedures could also be laid down mutually by the ICAR and CSC.

47.2.10 The Interim Report under reference laid due emphasis on the enforcement of the Seeds Act and certification programme. Despite the emphasis by the SRT and this Commission, most of the Seed Inspectors, who have been appointed by the States so far, are doing this job in an ex-officio capacity. They are either the District Agricultural Officers or the Agricultural Extension Officers. Such officers have multifarious duties and the enforcement of Seeds Act is just an additional piece of work for them. In some States, the Seed Development Officers at the headquarters or district levels are entrusted with this task but even in such cases, their main job is developmental and not enforcement. Seed Inspector exclusively for the purpose stipulated under the Act is yet to be notified in most of the States. Insofar as seed certification is concerned, the position is also none too happy despite earlier recommendations. To begin with, the NSC was assigned this task. This arrangement was to continue until the State Governments had appointed their own seed certification agencies. This was necessary because the agency, involved in the production of seed either at the foundation level or at the certified level, should not also be the certifying agency. This object has not been fulfilled so far. First of all, in many States, the NSC is still continuing the certification work. Secondly, wherever the States have undertaken this work, it has just been assigned to their Agriculture Departments, who still have some role or the other in the production programme. What was desired was that the State Governments should set up self-supporting independent seed certification agencies, to be run on 'no-profit no loss' basis. In order to set right this position effectively, an amendment to the original Seeds Act known as the Seeds (Amendment) Act (55 of 1972) was passed by the Parliament on September 9, 1972. The Central Government has been authorised to establish a Central Seed Certification Board (CSCB) to advise the Central and State Governments on all matters relating to certification and to coordinate the functions of the state seed certification agencies. The CSCB has been authorised to appoint as many committees as it may deem fit for the discharge of its functions. The Board had already been constituted in practice under the CSC in April, 1971 and the above Act merely gave it a statutory recognition. The Board had circulated models for the constitution of the State Seed Certification Boards (SSCB) and the allied seed certification executing agencies in February, 1972 among all the States. The State Governments are understood to be considering these models.

47.2.11 A survey of what has already been done or contemplated has been provided in the foregoing paragraphs. Problems have al-

ready cropped up in implementation and these will arise in future. It is expected that the CSC, the ICAR and the governments will be able to evolve such a working machinery that current problems are attended to periodically as these arise. The CSC has to become a very effective instrument in decision-making and solving the problems of the various facts of the seed programme. The CSC, as constituted today, will not be able to cope up when the work expands to all kinds of crops. It is, therefore, necessary that the CSC constitutes separate subcommittees for dealing with specialised groups of crops. For example, there can be separate subcommittees for fodder crops, sugarcane, root and tuber crops, vegetables, fruit and plantation crops and ornamental crops. Even the NSC can have specialised wings for such crops in its organisation.

3. MEASURE TO MAKE SEED BUSINESS ATTRACTIVE

47.3.1 Besides various other factors, which have an impact on the cost of seed production, the size of holdings is also a crucial factor. The cost of production is likely to be less if the size of holding is large within manageable limits. Efficient and quality seed production demands isolation from other cultivated lands and large scale plant protection measures. These requirements are fulfilled if the land area used for seed production is large and consolidated. This is the basis of the 'compact area approach' advocated for seed production, but it goes in favour of the big farmers. In order to make possible the participation of small farmers, it is necessary that they should be organised to pool their land resources into compact and viable units. The certified seed agencies which have to depend on the resources of small farmers to a considerable extent will have to educate and encourage them to join together on a voluntary basis. In this task, the State Governments will have to back the agencies with all possible administrative and financial measures.

Seed Crop Insurance

47.3.2 Multiplication of seed which requires high technical standards involves substantial investment. This is specially so in the case of foundation and certified seed. There is the risk of rejection of seed in the course of certification. Seed production, like any other field venture, is also prone to losses due to adverse weather. Substandard quality of seed may not all be due to the fault of the grower, it might be the result of poor quality of breeder or foundation seed. There is a legitimate case for compensating the seed grower in all such instances

where the loss to him does not occur due to his negligence. Seed crop insurance can really meet the situation. It has an added advantage of enabling commercial banks to finance seed production. Foundation seed agencies, which have to plan often two seasons ahead of actual seed production, need definite commitment and assurance for off-take. Therefore, they demand advance cash deposits from seed producers for supply of foundation seed. This arrangement puts hardships on seed growers, who can ill-afford to pay cash. Crop insurance, if introduced, would entitle the agencies to receive necessary bank guarantee which should satisfy them. The system of cash deposit prevalent at present may be eliminated in this way. The scope, manner and terms of seed crop insurance require to be determined and then tried on a trial basis before general application. The Union Ministry of Agriculture and Irrigation should take the initiative in formulating the scheme.

Remissions

47.3.3 Many State Governments have to impose a levy on foodgrains in times of scarcity. There have been instances when a levy has been imposed even on seed. This is due more to the ignorance of the operational staff in distinguishing seed from grain than to motives of the concerned orders. However, the ambiguity can be eliminated by mentioning in the orders themselves that certified and treated seed marked 'poison' should be exempted from such levies. Similarly, there have been suggestions for exemption from octroi and sales tax. Besides contributing to higher cost, such impositions introduce disparity in the sale price of the same seed in different places, because the local taxes vary from place to place. Such disparities can discourage popularisation of concerned seed brands. Owing to these reasons, the case for exempting seed from local taxes is justified.

Discontinuance of Detrimental Practices

47.3.4 The Departments of Agriculture in many States have been advancing certain seed varieties of crops to farmers without any cash transactions but on the assurance that at the end of the harvest the farmers concerned would return the quantity of seed taken plus 25 per cent extra of the same varieties for which the seed advance was given (*sawai* system). The intention is good so that the poor farmers who cannot afford cash could yet have seed of good varieties, but in practice this has not yielded the desired result. The farmers sometimes do not sow the same seed, but use it as food out of necessity. At the

end of the season they purchase from the market some grain of the same crop but not necessarily of the same variety and quality, and return it to the seed store for completing the formality. It has also come to our knowledge that in many States the departmental and cooperative seed stores are dealing in uncertified substandard seed worth crores of rupees. Some of the States procure grain from the Food Corporation of India and sell it as seed. Such undesirable practices like the sawai system or dealing in substandard seed will have an adverse impact on the sale prospects of genuine certified seed. These should be discouraged in general and the Governments or autonomous bodies or organised seed agencies should never resort to them. It should be realised that harm done in a season by wrong circulation of seed can take years to remove the ill effects.

Processing, Packaging and Storage

47.3.5 Production of seed in field stops at providing the 'true to type' raw material, but its conditioning for viability and sale is also a very essential step, which is linked with the post-harvest operations of processing, packaging and storage. Even the manner and speed of transport can make or mar the quality and prospects of seed material. The operations of processing, packaging and storage must necessarily develop as an integral part of the seed industry in order to make it remunerative. A reference is invited to Appendix 47.1 wherein the requirements of processing plants and storages for seed have been worked out. The breeder seed institutions and the foundations and certified seed agencies are required to have their own processing plants and storages. The number of seed processing plants and storages each required with the breeder seed institutions and foundation seed agencies will be about 150. It may not be difficult for them to own them. The foundation seed agencies might experience some financial difficulty to build storages which will have to be a condition. The network of processing plants and storages alike is envisaged to go down upto taluka level. In addition, seed storages of small capacity are planned to be available even in the interior at a rate of one for every 5 km radius. This is an ideal picture of distribution. In practice, it will have to depend upon the economic viability of the project in different places. What is pertinent to note here is that the number of organised seed agencies is contemplated to be only 360 for the whole country, whereas the number of processing plants and storages required for certified seed would be too large to shoulder the burden of their construction and management. The State Governments will have to step in to solve their problems in this regard. It is not necessary for the Governments to participate directly, what is needed is their

advice, financial assistance and assistance in the form of procuring essential equipment. It will be ideal if all the organised seed agencies—whether foundation or certified—and individual seed growers can be encouraged to form limited concerns on a regional basis to own and construct a network of seed processing plants and storages throughout the country. In fact, packaging could also profitably be brought within the functions of these concerns. The salient features of the three components, viz., processing, packaging and storage are now discussed separately.

47.3.6 Processing : Processing is the most important of these operations under consideration and involves drying, shelling or threshing, preconditioning, cleaning, size grading, upgrading and chemical dressing of the seed material. Certification at present is not compulsory but processing has got to be, otherwise it would be difficult to adhere to the required standards. It is absolutely essential that all operations commencing from threshing have to be performed separately from the commercial crop. It may be cited for example that one of the handicaps in maintaining purity of cotton crop is the mix-up that results from ginning the seed material in the commercial ginneries only. For this reason, there is no escape from providing separate processing machinery commencing from the threshing stage onwards for seed purposes. Processing equipments in use in the country were mostly obtained from foreign countries. If there has been any attempt to manufacture some within the country, it has been in the direction of developing only the prototypes. First generation equipments such as small air screens, seed cleaners, vertical bucket elevators, belt conveyors, seed treaters, moisture testers, dryers, threshers, shellers and bag closers are being fabricated in the country now.

47.3.7 Problems of securing specific type of steel, sealed bearings, precise screens, precision safety controls are being faced by the manufacturers, who are still in the small scale category. Sheet, sructural steel, alloy steel, special sheets for screen manufacture etc. are not available to them at controlled prices. The transport facility for steel given on 'full wagon load basis' cannot be taken advantage of by the small scale manufacturers. These bottlenecks have to be removed. What is still imported includes special separation machines, such as spiral separators, indented cylinders, specific gravity separator, aspirators, stoners, soyabean and other bean threshers, roll mills, large capacity seed cleaners, improved seed dryers, automatic filling and packaging/or bagging machines and dehumidifiers. Import of these equipments and machines has to be allowed on a liberal scale until these are developed indigeneously. It is very necessary that indigenous manufacture replaces imports to a great extent, and that designs should also be original and suited to our conditions. Gauges of

imported machinery are not perfectly suited to clear the produce as it comes from harvest under the country's average conditions owing to the presence of a lot of admixture of grain and straw of different sizes and shapes. The Industry Development Centre (IDC) of the NSC is meant for this very purpose. It will be necessary to prescribe specifications to help the manufacturers and test the manufactured machinery. In regard to other kinds of machines, tools etc., the sole national body to prescribe and test standards is the Indian Standards Institution (ISI). The IDC and ISI should collaborate closely to develop suitable specifications and set reasonable limits of performance, keeping in view that rigorous specifications at the development stage may be hard to comply with. In order to provide incentive to individuals, a system of prizes and royalties may be introduced.

47.3.8 Packaging : Packaging comes at the end of processing operations. An essential pre-requisite for packaging is that the moisture content of seed should be low, say 8-9 per cent or less. Then the object of packaging is to protect it against external moisture, pests and mechanical damage. Seed is usually packed in cotton and jute canvas, hessian and gunny bags with or without polyethylene lamination, while vegetable and flower seed is packed in paper, plastic or cloth containers. This kind of packaging does not ensure either protection against external moisture or tearing or insect pests, rodents and vermins. Packages for processed seeds in foreign countries are made up of burlap jute, cotton cloth, metal and paper films, glass and fibre board and various combinations of these materials. Jute and cotton bags are laminated with materials like polyethylene. Paper products are extensively used. Aluminium foil is also used. It is bonded to other materials to produce combinations having desired characteristics. Metal containers are also used. These, when properly sealed, provide an effective barrier against moisture and gases and shield the product from light. Such packing materials and packages should be developed in India. The materials so developed should also be amenable to printing so that contents, grade and quality and instructions for users can be suitably indicated on them. The Seed Technology Division of the IARI, IDC and the Indian Institute of Packaging (Bombay) could profitably collaborate in this regard.

47.3.9 New techniques in packaging are also coming in with the advances in research in technological fields. Vegetable seed is often tiny and the requirements of individual growers are small because of low seed rate and small size of holdings. Therefore, seed packets will have to be very small and moisture proof. Because of the processes of making moisture proof small packets, sealing becomes cumbersome and costly. To obviate this difficulty a practice is followed in some countries whereby the seed itself is coated by some non-toxic

chemical. The nature of chemical is generally kept a secret. Another way in seed packaging already initiated in some advanced countries envisages embedding of seed on soluble tapes at the required distances of planting. The tapes have an advantage that these could be rolled, transported and stored with convenience and planted intact merely by unrolling. This way of packaging is also ideal for vegetable crops and it has utility in conducting small scale trials in the case of other crops too. Researches in packaging should also consider such innovations.

47.3.10 Storage : The factors which influence the storage life of seed are the oxygen and carbon dioxide contents of the air around the seed, exposure to direct sunlight, humidity and temperature; of these the last two are the most important. Fungal and insect activity increases to the detriment of seed quality when the relative humidity and temperature of the store are higher than 40 per cent and 20°C respectively. Breeder seed requires to be stored at about 5°C and if so done, its viability and vigour can be retained for as long a period as 5-6 years and this in turn can obviate the need for multiplying the seed at shorter intervals to some reasonable extent. The rigorous of temperature requirements for foundation seed, which needs to be stored upto about 2-3 years only, are a little less (5 to 15°C). Both these stages of seed, therefore, require airconditioned storages. The storage for certified seed should only be damp proof with adequate protection against heat and leakage. It is desirable that the roof of the stores is made of RCC and walls and floors are made damp proof by coating with bitumen and a thin layer of polythene. Seeds should be stored on wooden pallets so that bags do not touch walls and floor and pick up incidental moisture. Exhaust fans are also beneficial to provide air circulation so that foul air contaminated with fumes etc. is eliminated. It is understood that some universities and research institutes do have special cold storage facilities for germ plasm and breeder seed. It is not difficult for other breeder institutions also to build such facilities. The main problem lies in making available the storage facility for foundation and certified seed; their solution has already been discussed.

Transport

47.3.11 One of the crucial considerations in the transport of seed is speed, because of the short duration of sowing operations. Delay in seed movement at the peak period makes all the difference between success and failure of crop performance. Therefore, all facilities of movement of seed at the proper time have to be geared. For short distances, truck transport will predominate, but for long distances rail

transport is inevitable. Rapidity of movement, even by air has to be thought of in emergent situations. Concessional air freight has to be decided for such exigencies. Railways have to ensure that the required number of wagons are released in time. Wagons should be leak-proof and insulated so that moisture and heat do not damage the seed. A very high priority will have to be given to seed movement so that it is not held up in transit and for this purpose wagons will have to be marked suitably in order to indicate that they are carrying seed material.

4 MEASURES FOR QUALITY IMPROVEMENT

47.4.1 The Agricultural Produce (Grading and Marking) Act of 1937, which is operative in the field of agricultural marketings, is meant to regulate through Marketing Inspectors the quality of agricultural produce in general for marketing purpose. The Seeds Act (1966) is meant for transactions in seed used for raising crops and is enforced through Seed Inspectors. Thus, the two Acts are distinct and they are enforced through two different agencies. However, dealers in seed are often checked by the marketing staff also under the first Act. Besides duplication, this causes harassment and inconvenience. It has to be clearly brought out that seed is not meant for consumption and, therefore, should be exclusively regulated through the provisions of the Seeds Act alone. The Seeds Act is basically regulatory in nature and is meant to ensure that seeds of notified varieties offered for sale conform to certain minimum limits of purity and germination. The enforcement machinery should try to educate dealers and encourage them to maintain proper norms rather than take penal actions. Seed industry is a developing one and, therefore, the Seeds Act should not unnecessarily frighten seedsmen so that they shy away from the industry. When seeds do not conform to standard, issue of 'stop sale' and withdrawing of seeds from the sale premises would in itself work as a sufficient deterrent. Only in cases of intentional and flagrant violation should legal action be taken.

47.4.2 The Seeds Act has been formulated in the infant stage of the seed industry. Many lacunae are being noticed in course of its enforcement. For example: (a) it does not provide licensing and registration of dealers; it may become difficult to enforce the Act if they are not licensed or registered, because they can always lead when caught violating the provisions of Seeds Act that they are not dealers; (b) the provision of minimum germination standard does not really give a choice of selection to the purchaser with respect to a variety which will give the maximum germination; and (c) the enforcement

of seed law is at present restricted to the kinds notified or varieties and excludes many other inferior ones. It may be noted that the Seeds Act is applicable to seed and propagating material of only agricultural crops in the groups of food crops (including edible oilseeds, pulses, sugars and starches, fruits and vegetables), cotton and fodder. The release of varieties of sugarcane, tobacco, jute, oilseeds, arecanut and spices is governed by their respective directorates. Similarly, variety release in the case of tea, coffee, rubber and cardamom is regulated by their respective boards. Because of this difference, many of the aspects regarding seed research, production, introduction, release and registration of varieties are not governed by uniform standards. Many such lacunae will come to notice in future. It will be prudent to wait and work through conventions within the framework of the existing law rather than rush for amendments every time. In due course a comprehensive law should be enacted. All the crops have to be ultimately brought under one Seeds Act, but until then an understanding with other concerned bodies is necessary for adopting common standards.

Provisions of Grow-out Tests in Seed Testing Laboratories

47.4.3 Seed testing laboratories have already come up in majority of the States. The IARI and NSC have also their own laboratories. The IARI serves as the Central Seed Testing Laboratory. The Forest Research Institute, Dehradun, serves as the testing laboratory for fresh seeds. These laboratories conduct routine analysis of seed samples, which is generally confined to evaluation of physical purity, germination and moisture. Tests for genetic purity are still uncommon in most laboratories. It is recognised that genetic purity evaluation is of great utility for seed laboratories, certification agencies, seed law enforcement agencies, seed trade and the farmer. To the certification agencies, such tests provide information on the quality of seed certified by them, thereby enabling them to locate and remedy defects in procedures and standards. To the enforcement agencies and the farmers, the tests give an idea of the quality of seed in circulation, thereby helping them to locate possible sources of good and poor quality seed. Three main tests, viz., laboratory test, green house or growth chamber test and field plot or grow-out test are generally useful for determination of genetic purity. Field plot or grow-out test is made under field conditions. The first two can provide preliminary data, but a field trial is essential for a final verdict. Apart from genetic purity, grow-out test provides useful information on the levels of field emergence which determine vigour and viability. At present, seeds are revalidated on the basis of laboratory germination test. Labora-

tory and field tests may not agree closely specially when seed viability is low. Infection carried in seed can also become manifest in field trials. Field test at specified soil moisture levels is, therefore, an absolute necessity. Seed testing laboratories are the best places where grow-out test can be conducted, because these are already analysing service samples, certification samples and control samples and the field work will be just in continuation of the same.

Compulsory Certification of Hybrids and Seed Material of Vegetatively Propagated Crops

47.4.4 Hybrid seed production involves production and maintenance of parental lines, at least two seasons ahead of actual seed production, and the evolution of parental lines especially in maize requires continuous inbreeding with selection for as many as six to seven generations. Being inbreds, the parental lines are relatively poor yielders and, therefore, are costly to produce. Error in hybrid seed production will not give the desired cross and will nullify the expensive and laborious efforts made in the evolution of the line and in the production, maintenance and stocking of its breeder and foundation seed. Further while with most crops improper roguing may not cause damage provided the foundation seed is relatively pure improper detasselling or inadequate isolation with maize can cause irreparable damage even in pure foundation seed. Genetic impurity in a hybrid resulting from such production can be detected only with difficulty even in grow-out test with seed claimed to be hybrid. Hybrid seed requires to be renewed every year for the maintenanc of original yielding level, while in other cases, the renewal period may be longer.

47.4.5 Like the hybrids, vegetatively propagated crops have also their special problems. The use of degenerated stock is one of the stumbling blocks in increasing their yield. Many diseases and pests are carried in succession from crop to crop through seed. In the case of sugarcane, pests like borer larvae, mealy bugs and scales and diseases like red rot, virus mosaic, grassy shoot and ratoon stunting are all transmitted through setts. Therefore, setts meant for multiplication of sugarcane seed require screening. Because of the pernicious nature of seed borne diseases, specially virus, production of seed potato in the plains according to the seed plot technique requires : (a) thorough removal of mild mosaic infested plants within 25-30 days of planting and well before contact between plants occurs, (b) perfect dehaulming before a prescribed date to escape aphid incidence and thereby virus transmission through them, and (c) complete prevention of regrowth after dehaulming. Slightest delay and defect in any of these processes may lead to transmission of the virus in seed potato

and to the outbreak of disease and consequent reduction in yield. It is well recognised that freedom of potato seed from disease (most disastrous being viruses) is a single factor determining the quantum of potato production in the country. So is the case with other crops propagated through stem cuttings, rhizomes or suckers. Thus, there is an obvious need for an impartial check on seed production without exception in the case of hybrids and vegetatively propagated crops. The objective of impartial check can be fully achieved through certification because certification processes automatically involve the requisite steps like verification of seed source, field inspection, seed testing and tagging and sealing. Though certification is at present a voluntary process, it should be made to apply to these special categories without exception.

Indication of Minimum Renewal Period in Certificates

47.4.6 A mention of the number of generations upto which the seed could be multiplied from the produce of the previous crop without resort to renewal is another important aspect, vital for the maintenance of quality seed. Crop varieties can differ in their reaction to so many factors, viz., seed borne diseases, pollination behaviour, compatibility, germinability, etc. For instance, in the case of the mustard group of crops, some varieties are self-sterile even within the species, while some others are self-fertile. Similarly, germinability in soyabean, dormancy in paddy, seed hardness in legumes, susceptibility to loose-smut in wheat etc. differ among their respective varieties. The standards for seed certification can be prescribed broadly crop wise. The breeders or breeder institutions sponsoring a variety for release have to state if in subsequent seed increases under certification the variety can in all respects live up to the crop standards prescribed for certification. Time limit up to which subsequent multiplication can be practised without deterioration of standards should also be indicated.

47.4.7 Production of certified seed from certified seed is permitted upto two generations after the stage of foundation seed, provided it is determined by the certification agency that the genetic purity will not be significantly altered, and up to three generations from foundation seed in the case of highly self-pollinated crops. Evidently, this description does not specify the crops or varieties which are highly self-pollinated or whose genetic purity will not be distinctly altered and thereby leaves the decision in this regard to the discretion of the certification agency. As certification agencies would be many, there can be variation in their discretion. Hence, it is very necessary to specify seed renewal periods on a scientific basis for as many crops as possible

for common adoption. The Central Certification Board can look into this aspect.

5 SEED RESEARCH, EDUCATION, TRAINING AND ORGANISATION

47.5.1 Seed research according to modern concepts is fairly new to the country. Almost complete reliance had to be placed upon foreign know-how when seed programmes were initiated in the sixties. The processing and packaging machinery was all imported. Foreign standards were also adopted for use in laying down specifications for testing and certification, isolation distances, environmental and seed conditions for storage etc. Problems typical to the country still abound practically in every sphere whether it relates to breeding of seed itself or its multiplication and maintenanee of quality in various post-harvest operations. Time of planting and methods of cultivation are required to be studied from the point of view of producing maximum quantity of high quality seed. For example, it has been shown in soyabean that the quality of seed can be considerably improved if the seed crop is planted late in September. Information is also required on the plant population, manurial and optimum irrigation requirements for producing high-quality seed. In the field of plant protection, isolation distances are extremely important. For example, the distance upto which a wheat plant infected with loose smut can infect other plants is not known. The distances fixed at present are mostly arbitrary and, therefore, require experimentation.

47.5.2 Very little information is available on seed contamination and pathology. Control of diseases and pests through seed treatment and procedure for production of disease-free seed has to be studied in detail. How much incidence of a disease should be permitted at various stages of inspection for seed certification? What are the methods available to reduce or eliminate seed-borne infection? What are the optimum storage conditions which would reduce biodeterioration of seed? There are answers to some of these questions in relation to certain diseases, but the information is often inadequate. For example, it is now known that stalk rot of maize caused by *Cephalosporium acrenium* is seed-borne, but, it is not known how much seed from infected plants has to be permitted, if at all, to go to the seed processing plants. The same questions arise in relation to several other diseases, such as, cob rot due to *Fusarium moniliforme* in maize, bacterial blight and *Helminthosporium* blight in paddy, ear cockle and karnal bunt of wheat and pol blight (*Collectotrichum truncatum*), bacterial pustutle and ringspot virus of soyabean. Attempts should also be made to develop easy keys for identification

of seed-borne pathogens during routine seed testing. Studies on the correlation of percentage of infected seed in a lot with disease incidence in field have to be carried out. This would help in arriving at minimum disease incidence tolerance to be prescribed for seed certification.

47.5.3 Seed maturation studies are needed to reveal as to when a seed becomes germinable after fertilization, reaches physiological maturity, and attains minimum viability vigour and the relationship of field maturity to changes in moisture content. Physical maturity and moisture relationship can help to determine the stage of field maturity at which seeds have maximum vigour and can be harvested with minimum damage. Specific information on moisture and storage relationship of seeds of many species is not available. There is considerable scope for research to determine safe environments for both short and long term storage of seeds under various climatic conditions. In the area of purity analysis and seed testing, methods need to be developed to overcome discrepancies in germination results caused by uneven ripening of the seed in the inflorescences of some species like jowar and bajra. The field of developing quick viability test is wide open.

47.5.4 It should be easy to realize that production of seed away from traditional areas has many advantages. A beginning in this direction has already been made in certain crops. For example, jute seed production is now taken up in Maharashtra and also in the Tarai area around Pantnagar, because the production of seed in the main growing region is not sufficient to meet the needs. Seed production of hybrid bajra is taken up in Karnataka and Maharashtra to avoid the crosspollination effect which is inherent in the usual bajra producing areas. Soyabean seed does not give good stand of crop under all conditions; there are only a few areas where it has been possible to produce good quality seed. Sunflower seed production has also to be taken up in specified areas where better filling of the head is obtained and where technical know-how for continued selection during the production of seed crop would be readily available. Areas far away from the popular places of production have an advantage of being free from the prevalent pests and diseases. For all these reasons, it is necessary to explore and demarcate experimentally the best possible seed producing areas for every crop. Irrigated areas of Rajasthan can also prove useful for seed production, because dry climate provides a natural advantage of freedom from pests and diseases. Rajasthan can easily specialize in various kinds of cucurbit, forage and fruit seeds. Cotton is another crop in which it can specialize for seed production. This aspects has already been referred to in our Interim

Report on Desert Development. The problems with regard to some important crops are discussed in the succeeding paragraphs.

Sugarcane

47.5.5 This crop has a long history of development and though the country is flooded with Coimbatore canes, yet the seed, that is used by cultivators, is commonly the degenerated stock representing their own field produce carried over from year to year for seed purposes. This situation has to be rectified urgently as it is one of the main causes for low yields. The planting material has to be made disease-free. A technique of heat treatment of setts has recently been developed, which eliminates pre-existing infections of certain internal seed-borne pathogens. The treatment has been found efficacious to control virus diseases like ratoon stunting and grassy shoot and fungal diseases like wilt and smut. All such useful results have to be properly utilised. Special attention should also be paid to multiply sufficient quantity of seed material suitable for every tract. Whereas the usual agencies have to be utilized for multiplying foundation and certified seed, the responsibility for breeder seed should lie with the Central Sugarcane Research Station, Coimbatore. As the breeder seed will be required for different parts, which are agroclimatically different, it will have to take the assistance of the research stations situated in different States.

Fodder Crops

47.5.6 Fodder crops represent a very wide spectrum of plant species and the primary obstacle in their improvement is the paucity of varieties exclusively developed for fodder purposes. Additionally, the large number of fodder crops involved in itself makes difficult the task of production of seed of each one of them and in many cases, e.g., some legumes and grasses, specialised knowledge and skill are required. Even in the case of better known crops like lucerne and berseem, seed material of high quality is not available in abundance, because their seed yield is either low due to poor setting in the absence of desirable pollinator insects or due to some other reasons. As far as grasses are concerned, the seed problems are acute even more. Many of the grasses have long dormancy periods, because of which either plenty of seed has to be used or there has to be some accurate knowledge of the duration upto which seed can give the best germinability and remain viable. According to R.O. Whyte[1], in 1957 the know-

[1] Whyte, R.O., The Grassland and Fodder Resources of India, Revised Edition 1964, ICAR (Monograph 22).

ledge and research on the physiology and morphology of Indian grasses and legumes and on the production, control and distribution of seed of improved varieties had not then reached a stage at which some good overall picture could be drawn. The picture is a little better now in as much as the Central Arid Zone Research Institute. Jodhpur and Indian Grassland and Fodder Research Institute, Jhansi are seized of the problems. An all-India Coordinated Project for Research on Forage crops is also functioning since 1970. The Union Ministry of Agriculture and Irrigation runs seven regional fodder production and demonstration centres at Hissar, Suratgarh, Kalyani, Dhamarod (Gujarat), Srinagar, Madras and Hyderabad. The Centres supply seed also to the adjoining States. Despite these developments, rapid and appreciable progress is yet to be made. Increased attention will have to be given to the production of adequate quantities of good quality seed of all kinds of fodder crops. The State Departments of Agriculture will have to take direct responsibility in planning and encouraging this kind of work with the help of established foundation and certified seed agencies.

Horticultural Crops

47.5.7 All horticultural crops—whether vegetables, flowers, fruits or plantation crops—suffer from a common defect that disease-ridden varieties of unknown purity and performance are commonly in circulation. Evolution of varieties with desirable characteristics has to await the results of persistent researches over a long period, in consonance with our recommendations made elsewhere. Meanwhile, some short term measure is very necessary for effecting immediate improvements. Screening of the existing varieties seems to be the only effective step to begin with. Planting material has to be multiplied only of the selected varieties. Besides this general point, each class of horticultural crops has its own problems. In case of vegetables, it may be stated that the growers are usually small landholders. Vegetable seed is minute in many cases and it is difficult to grow. In many cases, it is not possible to raise this seed everywhere due to climatic requirements. The result is that seed growing is beyond the capacity of all vegetable farmers, because of which they have to rely on someone to supply them seed in sowing seasons. This type of demand and dependence has given rise to a set of merchants who have specialized in the seed business. Therefore, it is not surprising that vegetable seed industry is one of the oldest in this country, but if its *modus operandi* is critically examined, it will be found that the seed concerns have been mostly operating as intermediaries between the sources of production and the needy growers. In the earlier

days, the source was foreign for many temperate vegetables like cole crops, turnip, beetroot, tomato and capsicum, but with the gradual clamping of import restrictions, certain pockets have developed within the country in temperate regions like Srinagar valley, Himachal Pradesh, West Uttar Pradesh hills, Darjeeling, Kalimpong, Mahabaleshwar and Nilgiris. A hereditary class of vegetable seed growers have developed in such areas. As far as the plains are concerned, there have always been areas specially known for some chosen vegetable or the other, e.g., Fatehgarh and Kanauj for radish and watermelon, Lucknow for muskmelon (*kharbuza*) and slender cucumber (*kakri*), Nasik for onion, Poona for table cucumber (*khira*) and so on. In these areas too, there have been families who have done the same kind of seed raising job generation after generation.

47.5.8 The vegetable seed merchants have established lasting contacts with the hereditary seed growers—whether on hills or in plains. Their only job has been to procure it, pack it and sell it to the needy farmers. The position is exactly the same in case of flowers. In this process the quality aspect has never figured; rather it has been generally neglected. The only merit of this system has been that a constant timely supply of seed material has been ensured to the farmer. Another good point which emerges from this system is that the tracts and the hereditary seed growers can now be easily identified for different class of vegetables. If the State Governments take direct responsibility to develop those very tracts on scientific lines by providing seed of proven varieties, other inputs and better production technology, a breakthrough is possible in the shortest possible time. It is also worth considering whether the very type of material which is being cultivated at present in different tracts cannot in itself be improved rather than introducing an altogether new material. A malpractice of common occurrence has also entered the vegetable seed trade. It relates to the utilisation of the left over rubbish of the vegetable markets by unscrupulous elements for seed purposes. This defect can very easily be rectified if the local bodies are empowered with the backing of appropriate law to destroy all such material every night after the closure of the vegetable market. This applies equally to fruits like papaya.

47.5.9 In the case of fruit crops, a way of improvement common to all, is by establishing a chain of progeny orchards from breeder to foundation to certified stages. Seed material to growers must flow from only such orchards and the supervision and promotional measures must be the direct responsibility of State Governments. The Seeds Act includes under its purview materials like seedlings, tubers, bulbs, rhizomes, roots, cuttings, all types of grafts and other vegetatively propagated material. Considering, however, the general nature

of provisions of the Act and the plight of fruit and plantation crops, it seems very necessary that detailed codes are laid down to regulate the multiplication and distribution of seed and planting material of these crops through the progeny orchards. Some important suggestions, common to research and multiplication aspects, are mentioned below individually for a few important fruit crops:

(i) Papaya—Seed should be produced under controlled conditions through artificial pollination and bagging of selected types so that mixing is avoided.

(ii) Banana and Pineapple—Bud sports and mutations are frequent in these crops. Selection of the improved clone and rigorous multiplication of the progeny from that clone are essential for uniformity and improvement in production. The pace of progress in this manner can be slow because the number of progenies from a single selected mother plant will be limited, but experiments in Tamil Nadu, West Bengal and Maharashtra have shown that this situation can be improved by following the technique for multiplication from bits of the corm in banana in addition to the suckers and in the case of pineapple, the stem below the flowering shoot can be cut into small pieces and multiplied.

(iii) Guava—The orchards are at present mostly raised from seed, but fast deterioration is inherent in this method. Inarching, veneer grafting, air-layering and stooling can all provide an effective alternative through vegetative propagation. The first two vegetative methods carry a disadvantage that the progeny is influenced by the characters of the stock. Air-layering does away with this defect and, therefore, this method can be profitably used in multiplication programmes. Experimentally, air-layers have to be developed from a selected variety as a first step. Then, these air-layers are allowed to grow over a period of 3-5 years. This time gap gives scope (a) to judge the performance and (b) to permit ample branching. Then, as a third step, further progeny is secured from the branches of air-layers through stooling with due etiolation, ringing and hormone treatment (5,000 ppm of indol butyric acid). About 10 plants can be obtained in this manner per air-layer and the process is subject to repetition for further multiplication. This method can be given further trials for common adoption.

(iv) Mango—Mango is propagated by inarching, but both scion and stock of doubtful characters have been freely used in the tr[illegible]s the rootstocks for mango are raised from seeds, there is considerable genetic variation in them which

causes extreme variation in orchards. To rectify this situation, uniform rootstocks are required which can be secured either from nucellar seedlings raised from polyembryonic varieties or through clonal propagation from air-layers or cuttings. The air-layers on established cuttings can be multiplied with the same principle as explained in the case of guava. As regards scion, the prevalent practice is to allow a graft to grow for 2-3 years and then bend the whole tree and use all the branches for inarching even before the tree starts bearing with the result that the performance of the tree remains unknown. A better practice would be to select trees of proven performance leaving no room for chance. Once the parent material has been thus established, veneer grafting could be adopted for mass production, because it is found to be easy and cheap.

(v) Citrus—The major trouble in citrus plants in general is that of virus (Greening and Tristeza etc.). This trouble is avoidable through seed propagation. The method of seed propagation even now is common in this crop and, therefore, has to be retained in preference to vegetative methods, unless researches can produce virus-resistant rootstock. Another point in favour of retaining seed propagation in this crop is that citrus is mostly polyembryonic, because of which the seedlings are invariably in a position to maintain stable characters uniformity. In order to be certain of the 'true to type' progeny, a further precaution is possible, which consists of isolating a few mother trees and growing with them *Poncirus trifoliata* as a pollen parent and then resorting to control pollination. Poncirus trifoliata is a kind of citrus plant whose morphological characters are slightly different from the usually cultivated types. Because of this distinction, it becomes easy to isolate the nucellar and gametic seedlings. It is the nucellar seedlings which are then used for further propagation. Therefore, the use of *Poncirus* can be considered for general adoption in progeny orchards.

(vi) Cashewnut—The existing stands of cashew crop are usually poor and have been mostly raised through seed. Vegetative propagation through budding and air-layering is showing promise, which could be tried profitably. Out of the two, air-layering is found to be better.

(vii) Cardamom—Most of the cardamom plantations as present are infested with mosaic virus, whose vector is an aphid. The possibility of grading rhizomes for multiplication purposes in

the aphid-free period is worth trying in the same way as it has been successfully tried in the case of potato.

Research and Education

47.5.10 The above mentioned survey merely provides a bird's eye view of a very vast field which lies ahead for seed research. The ICAR is the proper agency to make a thorough appraisal of the general as well as cropwise problems and then organise an integrated programme of research involving the IARI, agricultural universities and other interested autonomous or private institutions. Arrangements should also be made for the introduction of suitable courses in seed production methods, seed physiology and health and seed technology, testing and certification in all agricultural universities both at the graduate as well as postgraduate levels. The IARI, Tamil Nadu Agricultural University and G. B. Pant University of Agriculture and Technology have already introduced some such courses. Their experience might be useful in formulating courses on a uniform basis for all the universities. Some suitable courses in the management aspects of seed business preferably at the postgraduate level have also to be formulated. These have to be introduced in the existing institutes of management as an interim measure until a separate specialised management institute with a bias towards agriculture, animal husbandry and rural sciences as envisaged in our Interim Report on Agricultural Research, Extension and Training is established. In addition, appropriate short term courses for training in seed production methods, seed technology and essentials of testing and certification work will have to be arranged for the personnel of the Agriculture Departments as well as for the producers, processors and salesmen. The responsibility for arranging these training courses lies with the State Departments of Agriculture as recommended in the Interim Reports.

Organisational set-up

47.5.11 It has throughout been our emphasis that the production and distribution of seed should be preponderantly private, whereas the involvement of Governments should be confined only to overall supervisory, advisory and fostering activities. In the governmental set-up, seed production, seed law enforcement and seed certification are required to be independent of each other in order to bring an unbiased and objective approach into the respective spheres. Therefore, it is necessary that the Departments of Agriculture—whether at the Centre or in States—should have three distinct wings each to deal with input aspect, law enforcement and certification. The Departments of Agri-

culture and Horticulture (wherever the latter exist separately) have to deal with various other inputs and laws too. It is suggested that separate divisions are created for inputs and law enforcement and aspects pertaining to seed are also looked after by them. Insofar as certification is concerned, the Central Seed Certification Board is already in existence together with its State boards and this arrangement is sufficient to take care of the third component.

47.5.12 With regard to the seed industry, which will be largely private, it will be necessary to organise it in an effective manner. There are a couple of associations of seed producers even now, but their number, scope and sphere will increase with the seed business in every State going down even to village level. The National Seeds Corporation was to perform two functions according to its original terms. It was required to have its own programme of seed production on commercial lines and at the same time it was also charged with the responsibility of helping the development of an exclusive seed industry. The second function is now required to be developed and for this purpose, a clear separation is needed between the commmercial and developmental activities. It should have a separate new wing, whose responsibilities should include training of personnel, establishment of new seed enterprises, and rendering of technical advice to banks and other lending agencies on credit and other financial needs of the seed industry. As the activities of this wing of the NSC expand and strengthen, seed growers, seed dealers and the NSC together with the State foundation seed agencies and many other well-organised certified seed agencies are bound to emerge as a well coordinated system having the basic unity of purpose and common methods of approach.

6 SUMMARY OF RECOMMENDATIONS

47.6.1 The Seed Review Team Report (June, 1968) should be considered as the base and the recommendations in this chapter should be read in continuation of the Commission's Interim Reports entitled (a) Multiplication and Distribution of Quality Seed pertaining to High Yielding Varieties and Hybrids of Cereals and (b) Potato Seed; the main recommendations are given below:

1. The programme of seed production in the country should be developed in future on commercial lines. The industry could be expanded gradually so as to be able to cater to the needs of other countries also. Even reputed foreign seed firms and scientists could be invited to collaborate in the seed production programme.

(Paragraphs 47.1.2 and 47.1.3)

2. The Central Seed Committee with the assistance of its State subcommittees can operate a system of national registry of varieties for the entire country—whether released by the Centre or States. A suitable registration fee could be charged for this work and inspection on site should constitute an essential step for issuing certificates. Necessary rules and procedures in this regard could be laid down mutually by the ICAR and the Central Seed Committee.

(Paragraph 47.2.9)

3. The Central Seed Committee, the ICAR and the Governments should evolve a working machinery so that the problems arising from time to time in the implementation of various reports could always be tackled expeditiously. It will be necessary for the Central Seed Committee to constitute separate sub-committees for dealing with specialised group of crops and the National Seeds Corporation could also likewise have specialised wings for crops.

(Paragraph 47.2.11)

4. In order to ensure full benefit to small participants, they have to be educated and encouraged to form 'compact areas' for seed production. Certified seed agencies, which will have to depend on small farmers, should be made to undertake directly this programme and the State Governments have to render assistance through all possible financial and administrative measures.

(Paragraph 47.3.1)

5. Promotional measures like (a) seed crop insurance, (b) exemption from levies operative for grains, octroi, sales tax or local taxes in any other form, (c) timely release of wagons in adequate number, their proper insulation and unobstructed rapid movement, (d) air movement of seed material and concessional air freight for the purpose are all very desirable. Detrimental practices like *sawai* system and sale of uncertified sub-standard seed has to be discouraged in general and the Governments, autonomous institutions and organised seed agencies in particular have to desist from taking recourse to those under all possible avoidable circumstances.

(Paragraphs 47.3.2, 47.3.3, 47.3.4 and 47.3.11)

6. The network of processing and storage plants should be made as widespread as possible so that the facility could be utilised by farmers in all parts of the country. At the same time their distribution should be compatible with the magnitude of seed industry, which will determine the ultimate economic viability of the project in different places. It will be ideal if all the organised seed agencies and even individual seed growers can be encouraged to form limited

concerns on a regional basis to own and construct the seed processing and storage plants. Even packaging can be included in their scope.

(Paragraph 47.3.5)

7. Seed procesing has got to be made compulsory and performed separately from the produce of the commercial crop. In order to cope up with the load, processing equipments and machines have to be manufactured within the country as an ultimate objective. Whatever little is manufactured at present under small scale industries suffers from inadequate supplies of basic materials, i.e. steel or various manufactured components like sealed bearings, precise screens etc. and even if the materials are available, these are not on controlled rates. Small scale manufacturers are put to a disadvantage even in procurement, because they cannot afford to pay for the whole wagon load, which is the basis of allotment at present. These bottlenecks have to be removed.

(Paragraph 47.3.6)

8. The Industrial Development Centre (IDC) of the National Seeds Corporation and the Indian Standards Institution have to collaborate in designing, making specifications for fabricating processing equipment and machines suited to Indian conditions for the benefit of local manufacturers and testing the same for performance. In order to provide necessary incentive to individuals, a system of prizes and royalties has also to be instituted. In the intervening period, when the country has to depend on imported materials, the Centre should liberalised its import policy with regard to the required items.

(Paragraph 47.3.7)

9. The Seed Techology Division of the IARI, IDC and the Indian Institute of Packaging (Bombay) have to join together in developing materials, methods and designs for ideal packaging to meet different requirements. New innovations like chemical coating of seed as developed in order countries for special crops and ready made 'seed on tape' have also to engage constant attention.

(Paragraphs 47.3.8 and 47.3.9)

10. Storages for breeder and foundation seed have to be airconditioned (both for temperature and humidity) and those for certified seed could be only damp-proof and free from pest attack,

(Paragraph 47.3.10)

11. The Central and State Governments should ensure that seed marketing is enforced only through the Seed Inspectors under the Seeds Act and not through the marketing staff under the provisions of the Agricultural Produce (Grading and Marking) Act or under

any other law. Clear orders are necessary to operational staff to remove any ambiguity which might be existing in this regard. Further, the Seeds Act should be enforced as far as possible through persuasion and educative methods rather than through penal measures.

(Paragraph 47.4.1)

12. Amending the Seeds Act should be deferred until experience and working with the Act have reached a stage at which a comprehensive bill could be brought forward to make it foolproof and reasonably comprehensive. In the meantime, conventions should be developed within the existing framework of the Act. For the same reason, working arrangements have to be made by the ICAR and Central Seed Committee with various directorates of crop commodities as well as boards of different plantation crops so that common standards could be enforced in all crops on a uniform basis.

(Paragraph 47.4.2)

13. Some of the aspects related to the Seeds Act which require pointed attention are specified below:

(i) Grow-out test should be made an integral part of seed testing. This job should be entrusted to seed testing laboratories.

(ii) Compulsory certification is desirable in the case of seed material of hybrids and vegetatively propagated crops.

(iii) In order to avoid chances of deterioration in the multiplication of seed at different stages, breeders or breeder institutions should specifically state about the chances of a variety to maintain the varietal standards as needed under certification and the Central Seed Certification Board should specify for each variety the time limit up to which subsequent multiplication can be practised without deterioration of the standards.

(Paragraphs 47.4.3 to 47.4.7)

14. There is need to undertake research under Indian conditions in almost all fields of seed production, preservation and standardisation. Seed ecology, biochemistry, physiology, pathology, entomology, breeding and cultivation aspects as also the laboratory or industrial aspects require attention. Physical constant of seed under various conditions and for various purposes also require to be determined.

(Paragraphs 47.5.1 to 47.5.3)

15. Congenial areas for seed production for every crop will have to be determined and developed through experiments. In this work special emphasis should be given to the selection or areas remote from the traditional areas of cultivation in respect of every crop. Specialised pockets of seed production already exist in the case of

vegetable crops, but the material being produced, pertains to varieties of unknown purity and performance. In their case, therefore, the need is to educate the traditional growers in the practices of growing quality seed and provide them with the requisite inputs and guidance. Another point for consideration could be whether their own material could not be improved upon rather than introducing new material.

(Paragraphs 47.5.4 and 47.5.8)

16. Necessary steps to tackle the seed problems of some of the selected crops are suggested below:

(i) Sugarcane—Multiplication of disease free planting material is the prime necessity. It is equally important to multiply sufficient quantity of seed material suitable for every track. Whereas the usual agencies have to be utilised for multiplication of foundation and certified seed, the responsibility for breeder seed should lie with the Central Sugarcane Research Station Coimbatore. This station should take the assistance of research stations situated in various States in order to get the benefit of multiplying seed for different agro-climatic conditions. (Paragraph 47.5.5)

(ii) Fodder crops—Fodder crops are many and may be classified into legumes and non-legumes. Increased attention should be given to the research and multiplication aspects of all these crops so that adequate quantities of good quality seed become available. State Departments of Agriculture should take direct responsibility in planning and encouraging this work with the help of established foundation and certified seed agencies.

(Paragraph 47.5.6)

(iii) Horticultural and Plantation Crops—In the case of fruits, vegetables, flowers and plantation crops, the first necessity is to screen the existing varieties in order to choose the best amongst them and then take measures to multiply the seed material of the chosen ones in adequate quantities. Seed material to fruit growers must pass through known pedigree orchards and for this it is very necessary to establish chain of progeny orchards from breeder to foundation and certified seed stages. The supervision and promotional measures with regard to progeny orchards must be the responsibility of State Governments. It is also very desirable that detailed codes are laid down within the purview of Seeds Act to regulate multiplication and distribution of seed and planting material of these crops through progeny orchards.

(Paragraphs 47.5.7 and 47.5.9)

(iv) Papaya—Papaya seed requires to be multiplied under controlled conditions through artificial pollination and bagging of selected types in order to avoid mixing.

(Paragraph 47.5.9(i))

(v) Banana and Pineapple—Clones of improved types and known pedigree are required to be multiplied for the sake of uniform and better production. Multiplication from bits of corm in the case of banana and from small pieces of stem below the flowering shoot in the case of pineapple increase progeny and therefore, this practice has to be encouraged after due trials.

(Paragraph 47.5.9(ii))

(vi) Guava—The vegetative propagation through experimentally proven methods such as by air-layering could be tried for multiplication.

(Paragraph 47.5.9(iii))

(vii) Mango—The important problem is to standardise the stock and scion in the case of mango. Nucellar technique could be utilised to develop uniform rootstocks or it can be done through clonal propagation by airlayes. Scions require to be multiplied from varieties whose fruiting performance has actually been verified. Once the parent material has been thus established, veneer grafting could be adopted for mass production.

(Paragraph 47.5.9(iv))

(viii) Citrus—The most important problem in the case of citrus is to produce virus free planting material for which, nucellar technique could be put to use to the advantage.

(Paragraph 47.5.9(vi))

(ix) Cashewnut—Vegetative propagation through budding and air-layering could be tried in multiplication work.

(Paragraph 47.5.9(vii))

(x) Cardamom—The possibility of grading rhizomes for multiplication purposes in the aphid-free period is worth trying in the same way as applicable to potato.

(Paragraph 47.5.9(vi))

17. The ICAR should take steps for introducing suitable courses related to seed production methods at the graduate as well as postgraduate levels in all the agricultural universities. Some suitable courses in the management aspects of seed business could also be introduced in the existing Indian institutes of management to begin with and later on such courses could form part of the curriculam of the specialised management institute with a bias towards agriculture,

animal husbandry and rural sciences as envisaged in the Commission's Interim Report on Agricultural Research, Extension and Training. In addition, short term training courses have to be introduced by the State Departments of Agriculture for training of the lower cadres as well as private seed producers, processors, salesmen etc.

(Paragraph 47.5.10)

18. The Departments of Agriculture at the Centre and in the States should have three distinct wings each dealing respectively with the input aspect, law enforcement and certification work. The Departments of Agriculture/Horticulture have to deal with various other inputs and laws too. It is suggested that separate divisions are created for inputs and law enforcement and aspects pertaining to seed are also looked after by them. Insofar as certification is concerned, the Central Seeds Certification Board together with its state boards would serve the purpose of the third wing.

(Paragraph 47.5.11)

19. The various foundation and certified seed agencies, which will be coming forth in future, will have to be organised in an integrated manner. The National Seeds Corporation could play a leading and purposeful role in this connection. It could create a distinct wing to look after promotional activities like the establishment of new seed enterprises, training of personnel and the rendering of technical advice to banks and other leading agencies on credit and financial needs of the seed industry.

(Paragraph 47.5.12)

APPENDIX 47.1

Magnitude of Seed Industry

(Paragraphs 47.1.3 and 47.3.5)

An attempt is made in this Appendix to estimate the extent of involvement in seed industry by way of area, quantity of seed, processing plants and storages and man power necessary to meet the needs of about 200 Mha of gross cropped area in 2000 A.D.

Seed Area and Production

2. Calculation of seed area and production depends upon the knowledge of the crop area to be sown, seed rate used for that area, seed rate and yield of seed crop (which will give the multiplication ratio), seed renewal period and seed multiplication stages. Basic data for calculating area and production pertaining to seed crops as in 2000 A.D. are given in Statement I. Seed rates have been assumed more or less at the existing level itself but the yields are assumed at higher levels. Usually, only about two-thirds of the production accruing from a seed plot constitutes the quantity of seed fit for sale because of sorting and grading etc. Even then, the produce of seed crop as compared to the corresponding field crop on per hectare basis under farmers' average conditions is at present more because of the low standard of the latter. This disparity is going to narrow down with the raising of general standards of cultivation in times to come, but the seed crop may yet have an edge over the field crop. However, it is difficult to pre-judge the extent of this disparity in quantitative terms for 2000 A.D. Therefore, the same standards of yields have been adopted for seed crops in that year as targeted for the field crops, which are in themselves 2-3 times higher than the existing ones. The basis of other norms has been explained in Statement I itself. The area and production of seed crops as in 2000 A.D. calculated on the basis of Statement I are given in Statement II.

3. An appraisal has also been made for 1985 just to give a comparative idea of an intermediate position (the total span being counted from 1976 to 2000). The relevant norms and corresponding calculations for 1985 are shown in Statements III and IV respectively. Only the targeted areas have been reckoned to begin with (i.e., in 1976). In the case of the important cereals, where some progress has already been made in the High Yielding Varieties Programmes, allowances have been made for coverage which could be expected by 1975 on the basis of targets and achievements. The allowance made in different crops is paddy 7.5, wheat 8.0, maize 0.7, jowar 1.6 and bajra 2.5 Mha. In the case of cotton, the position gets complicated because the ginning of seed, which the farmers use from their own crop, is done in the commercial ginneries only and, therefore, the likelihood of a mix-up always exists. Owing to this difficulty, no allowance for coverage under better varieties has been made for this crop, although the official figure of such coverage was 56 per cent in 1973-74. The areas which will be under high yielding varieties in 1985 have been worked out by fixing the period of coverage of the full area by such varieties in the following manner :—

C—3 Deptt. of Agri./76

(i) The period of coverage has been kept as 10 years, if the total area under a crop to be covered by quality seed is 1.0 Mha or less. Such a crop is jute. An exception has been made for wheat, in which case, even though the area is more than this limit, the period has been kept as 15 years only.

(ii) The period has been kept as 15 years for areas between 1.1 and 5.5 Mha or less. The crops are barley, ragi, pigeonpea, brassicas, sesamum and linseed. An exception has been made for paddy, in which case, even though the area is more than this limit, the period has been kept as 15 years only.

(iii) The period has been kept as 20 years for areas between 5.6 and 10.0 Mha. The crops are maize, *bajra*, gram, pea, groundnut and other oilseeds. Wheat, which falls under this category, has been placed in category (i).

(iv) The period has been kept as 25 years for areas more than 10 Mha. The crops are *jowar*, other pulses, cotton and fodder crops. Paddy, which falls under this category, has been transferred to category (ii).

4. The seed area and production as worked out for 1985 and 2000 A.D. are given below:

area = '000 ha
production = '000 tonnes

stage	1985		2000	
	area	production	area	production
breeder	0·17	0·13	0·12	0·11
foundation	9·41	8·07	10·03	10·56
certified	1,163·12	1,296·56	1,595·84	2,209·20
total	1,172.70	1,304.76	1,605.99	2,219.87

It may be noted that the area under seed crops will be about 1.60 Mha in 2000 A.D. to cater to the needs of a total cropped area of 175 Mha.

5. The area of field crops considered for seed calculations in 2000 A.D. is about 87.5 per cent of the then gross cropped area. The crops left over are sugarcane, tobacco, tubers, bulbs, other vegetables, flowers, spices and condiments and plantation, fruit and medicinal crops. Though these crops will occupy only the remaining 12.5 per cent of the gross cropped area, yet it does not follow that the area needed for seed or nursery purposes for them will also

bear the same proportion with respect to the overall area under seed crops. Keeping this point in view, it will be safer to assume that the area under seed and nurseries for these crops will be 20 per cent of the total seed area, meaning thereby that 1.60 Mha represents only 80 per cent of the seed area. If this is so, the seed area for the left-over crops will be 0.4 Mha.

6. It may be recalled that a surplus production of 25 to 50 per cent of breeder seed was recommended in the Commission's Interim Report on Multiplication and Distribution of Seeds of Cereal Crops, but the quantity of this seed being small it seems better to provide for a much bigger stock for the sake of future projection. The basis adopted at present for different stages of multiplication is twice the annual need in the case of breeder seed, 1.5 times in the case of foundation seed and 1.25 times in the case of certified seed. Accordingly, the estimates of seed area and production for 2000 A.D. would change to the following values:—

area='000 ha

production='000 tonnes

stages	area	production
breeder	0·24	0·22
foundation	15·05	15·84
certified	1,994·80	2,761·50
total	2,010·09	2,777·56

In this manner, the area required for seed production in 2000 A.D. will finally aggregate to 2.0 plus 0.4 (representing the share of left-over crops) = 2.4 Mha. The quantity of seed which will be produced in 2000 A.D. according to above calculations will be utilized for arriving at the estimates of processing plants and storages.

Number of Seed Processing Plants and Storages

7. Breeder seed will be produced only by (a) the agricultural universities, (b) Central and State institutes related to crop research and (c) similar private institutions. There are 21 States and 9 Union Territories and considering that the number of agricultural universities on an average will be one per State, although some States may have more than one and a few smaller States and Union Territories may have none, the total number of agricultural universities can be kept as 30 in 2000 A.D. Similarly, the total of Central and State institutes can also be kept at 30. Although private breeding institutions are only

a few at present, these are likely to increase in future: their number in 2000 A.D. may be assumed to be 10. Thus, the total number of institutions, which will produce breeder seed, will be 70. It is necessary in the interest of purity of breeder seed that each of these institutions should have their own seed processing plants and storages. The quantity of breeder seed being small, a capacity between 5 and 10 tonnes per processing plant or storage will be more than sufficient. Storages for breeder seed will require to be provided with temperature and humidity regulating mechanisms.

8. Foundation seed of field crops will be about 15,000 tonnes. It may be assumed that one-third of this quantity will relate to varieties of all-India importance, whose seed will be the responsibility of the National Seeds Corporation (NSC). Thus, the NSC will have to handle about 5,000 tonnes of seed. Supposing that its establishments will have to exist in every State, there may be about 25 processing plants and storages each in its charge.* The capacity of these processing plants and storages may be of the order of 200 tonnes each on an average. The balance of the quantity of foundation seed, viz., 10,000 tonnes, will fall in the share of other foundation seed agencies whose number could be assumed as follows:—

(i) one each in States to be set up by the governments . . =25

(ii) private agencies also @one per State on average . . . =25

The average capacity of these processing plants and storages alike will also have to be around 200 tonnes. The storages for foundation seed will have to be air-conditioned both with regard to temperature and humidity.

9. The quantity of certified seed will be about 2.8 or say 3 M tonnes. The production of this seed will involve a large number of certified seed agencies and individual farmers from almost all villages will also have to participate in this programme. Moreover, certified seed has to be made available within easy reach of all villages so that its non-availability in times of need does not become a constraint. Insofar as storages are concerned, the bulk of the produce should be stored at taluk points, while there should also be a provision to keep some quantity readily available at the assembling and sub-market centres (approximately 30,000), which are being proposed at the rate of one for every 5 km radius in Chapter 56 on Marketing, Transport and Storage. The capacity of storages in towns could be 1,000 tonnes, whereas it could be about 10 tonnes for a primary market centre. The processing plants, however, need not go into interior farther than taluk points. In this manner, the capacity of a processing plant for each taluk can be placed at 1,000 tonnes.

10. The number of processing plants and storages meant for certified seed is such that only the seed agencies will not be able to own them; the State Governments will have to think of some other means too to meet the situation. As far as construction requirements of certified seed storage is concerned, it will suffice if these are damp proof with adequate protection against heat and leakage. Some sort of storage arrangement is required to be introduced in

* The number of States and Union Territories may be reckoned to be 25 for the sake of calculations, wherever weightage is required to be given for size.

every village too so that individual farmers may learn to protect their seed material from deterioration. Seed box of approximately one cubic metre volume is a cheap contrivance, which can serve the purpose. If 50 seed boxes are provided for each village to begin with, that would mean 30 million seed boxes. Fabrication of these boxes will open up an added avenue of work and income to village artisans in the small sector.

Man Power in Seed Industry

11. The area under seed industry has been shown to be 2.4 Mha. If half of it is managed by organised seed agencies or well-to-do farmers and the other half involve the participation of small land-holders and if only 0.1 ha is utilized by every participating small farmer for growing seed crop, it will mean an involvement of 12 million farmers to make up 1.2 Mha.

12. It has been stated that about 30 million seed boxes will be needed in villages. Spread over a span of 25 years, this will mean construction of 1.2 million boxes per year and @ about 8 boxes per carpenter per month (i.e. approximately 100 boxes per year per man in round figures), it will mean an involvement of 12,000 artisans per year in this job.

13. The handling of air-conditioned processing plants and storages is a technical job which must be handled by graduates and postgraduates. The seed storages which are going to be provided at the assembling and submarket centres can be managed by the general staff which will be provided there. However, the processing plants and storages needed for breeder seed (70 each), foundation seed (75 each) and certified seed upto town level (3,000 each) will require exclusive attention of trained staff. It will be appropriate to provide gradudates or postgraduates at these plants and if it is assumed that one such person will be able to manage one processing plant and one storage, the number required will be 3,145. There will be many other jobs too for which graduates and postgraduates will be needed. A complete enumeration is made below:

(i) processing and storage	3,145
(ii) breeder institutions @ 4 per institution=70×4=	280
(iii) foundation seed agencies @ and average rate of 6 graduates per agency=75×6=	450
(iv) certified seed agencies @ 3 per agency and the agencies assumed to be atleast one per district = 360×3=	1,080
(v) seed testing laboratories @ 4 technical men per laboratory and laboratories @ 2 per State (the number of States reckoned as 25 for calculation)=25×2×4=	200
(vi) certification : per crop per State 4 graduates (one certification incharge, one certification officer and 2 graduate assistants) =50 crops ×25×4=	5,000
total .	10,155

14. The magnitude of seed industry as in 2000 A.D is summarised below on the basis of foregoing considerations:

area needed under seed crops and nurseries to provide seed and planting material for a gross cropped area of about 200 Mha	=2·4 Mha
breeder institutions	=70
processing plants and storages for breeder seed (capacity=5—10 tonne each) 70×2	=140
foundation seed agencies: NSC (considered equivalent to 25 because of its involvement in all the States with regard to all India varieties—30 States and Union Territories considered equivalent to 25 States) +one each in States to be set up by the Governments+private agencies also @ one per State .	=75
processing plants and storages for foundation seed (capacity—200 tonne each) 75×2	=150
certified seed agencies @ one per district	=360
small farmers participating in the production of certified seed (annual)	=12 million
processing plants for certified seed (capacity—1000 tonne). .	=3,000
storages for certified seed—	
(i) towns (capacity 1000 tonne)	=3,000
(ii) primary market centres (capacity 10 tonne) . .	=30,000
(iii) seed boxes for villages	=30 million
village carpenters for seed boxes	=12,000
graduates and postgraduates	=10,000

APPENDIX 47·1 (contd.)

Statement I : BasicData for Calculating Area and Production pertaining to Seed Crops as in 2000 A.D.

Seed crop	Crop area Mha	Seed rate for farmers' crop tonne/ha	Seed crop			Seed renewal period years	Seed multiplication stages			
			Seed rate tonne/ha	Yield tonne/ha	Multiplication ratio		Breeder	Foundation	Certified	Total
1	2	3	4	5	6	7	8	9	10	11
paddy (a)	32·00	0·030	0·030	4·55	152	4	1	1	1	3
wheat	17·55	0·075	0·075	3·64	49	4	1	1	2	4
barley	5·50	0·075	0·075	1·97	26	4	1	1	2	4
maize hybrid (b)	6·00	0·015	0·013	3·23	248	1	1	1	1	3
maize variety (b)	3·00	0·015	0·013	1·50	115	3	1	1	1	3
jowar hybrid (b)	11·34	0·010	0·008	1·43	179	1	1	1	1	3
jowar variety (b)	5.66	0·010	0·008	0·75	94	3	1	1	1	3
bajra hybrid (b)	8·00	0·006	0·004	1·52	380	1	1	1	1	3
bajra variety (b)	4·00	0·006	0·004	0·70	175	3	1	1	1	3
ragi	2·50	0·005	0·005	2·10	420	4	1	1	1	3
gram and peas	9·50	0·070	0·063	1·50	24	3	1	1	2	4
pigeonpea	3·00	0·012	0·010	1·50	150	3	1	1	1	3
other pulses (c)	12·50	0·015	0·012	1·50	125	3	1	1	1	3
groundnut	9·00	0.120	0·120	1·50	13	3	1	2	2	3

APPENDIX 47.1—(contd.)

1	2	3	4	5	6	7	8	9	10	11
brassicas	4·00	0·005	0·005	1·00	200	3	1	1	1	3
sesamum	3·00	0·005	0·003	0·60	200	3	1	1	1	3
linseed	2·00	0·015	0·012	0·50	42	4	1	1	2	4
other oil crops (c) . . .	7·50	0·012	0·010	0·73	73	3	1	1	1	3
cotton	11·50	0·020	0·020	0·92	46	1	1	1	2	4
jute	1·00	0·010	0·005	0·60	120	2	1	1	1	3
fodder (d)	16·50	0·060	0·008	0·60	75	4	1	1	1	3
total .	175·05 (which is approximately 88 per cent of the entire estimated gross cropped area as in 2000 A.D.)									

NOTES : (a) Yield relates to paddy—not rice.

(b) Proportion of area between hybrids and varieties has been arbitrarily fixed as 2:1 for the sake of calculation. The yields of hybrids and varieties are so fixed that these give the same overall production as targeted.

(c) Seed rate is assumed so as to be applicable to majority. Yield is so fixed as to add up to the overall production for the group as a whole.

(d) Calculated for jowar.

(e) Multiplication stages are fixed as follows :—

Multiplication ratio	stages
15 or less	5
16—50	4
51 and above	3

APPENDIX 47.1 (contd.)

Statement II : Area and Production of Seed Crops as in 2000 A.D.
Calculated on the basis of Statement I

Area = hectares
Production = tonnes

Crop	Breeder		Foundation		Certified		Total	
	Area	Production	Area	Production	Area	Production	Area	Production
paddy	2·3	10.5	346·3	1,579·1	52,631.6	240,000·0	52,080·2	241,589·7
wheat	0·8	2·9	37·7	137·2	92,246·7	335,778·0	92,285·2	335,918·1
barley	3·0	5·9	77.4	152.5	54,361·1	107,091·4	54,441·5	107,249·8
maize hybrid	0.5	1·6	112·3	362·7	27,863.8	90,000·1	27,976.6	90,364·4
maize variety	0·7	1·1	86·9	130·3	10,000·0	15,000·0	10,087·6	15,131.4
jowar hybrid	2·5	3·6	443·0	633·5	79,300.7	113,400·0	79,746·2	114,037·1
jowar variety	2·8	2·1	267.6	200·7	25,155.6	18,886·7	25,426·0	19,069·5
bajra hybrid	0·2	0·3	83·1	126·3	31,578·9	47,999·9	31,662·2	48,126·5
bajra variety	0.4	0·3	65·3	45·7	11,428.6	8,000·2	11,494·3	8,046·2
ragi	0·08	0·02	3·5	7·3	1,488·1	3,125·0	1,491·608	3,132·32
gram and peas	10·7	16·1	256·5	381·7	153,935·2	230,902·8	154,202·4	231,303·6
pigeon pea	0.4	0·6	53·3	79·9	8,000·0	12,000·0	8,053·7	12,080·5
other pulses	2·7	4·1	333·3	499·9	41,666·7	62,500·1	42,002·7	63,004·1
groundnut	8.4	12·6	1,529·3	2,293·9	258,461·5	387,692·3	259,999·2	389,998·8
brassicas	0·2	0·2	33·3	33·3	6,666·7	6,666·7	6,700·2	6,700·2
sesamum	0·2	0·1	41·7	25·0	8,333·3	5,000·0	8,375·2	5,025·1
linseed	0·2	0·1	8·5	4·3	15,357·1	7,678.5	15,365·8	7,682·9
other oilcrops	7·7	5·6	562·9	410·9	41,095·9	30,000·0	41,666·5	30,416·5
cotton	2·6	2·4	118·1	108·7	255,434·8	235,000·0	255,555·5	235,111·1
jute	0·6	0·4	69·4	41·6	8,333·3	5,000·0	8,403·3	5,042·0
fodder	73·3	44·0	5,500·0	3,300·0	412,500·0	247,500·0	418,073·3	250,844·0
total	120·208	114·62	10,029·4	10,557·5	1,595,839·6	2,209,201·8	1,605,989·208	2,219,873·8

APPENDIX 47.1 (contd.)

Statement III : Basic Data for Calculating Area and Production pertaining to Seed Crop as in 1985 A.D.

Crop	Crop area Mha	Seed rate for farmers' crop tonne/ha	Seed crop			Seed renewal period years	Seed multiplication stages			
			Seed rate tonne/ha	Yield tonne/ha	Multiplication ratio		Breeder	Foundation	Certified	Total
1	2	3	4	5	6	7	8	9	10	11
paddy (a) . . .	23·80	0·030	0·030	3·17	106	4	1	1	1	3
wheat . . .	17·55	0·075	0·075	2·81	37	4	1	1	2	4
barley . . .	3·70	0·075	0·075	1·69	23	4	1	1	2	4
maize hybrid (b) . . .	2·42	0·015	0·013	2·23	171	1	1	1	1	3
maize variety (b) . . .	2·42	0·015	0·013	1·07	82	3	1	1	1	3
jowar hybrid (b) . . .	3·88	0·010	0·008	0·99	124	1	1	1	1	3
jowar variety (b) . . .	3·88	0·010	0·008	0·52	65	3	1	1	1	3
bajra hybrid (b) . . .	3·62	0·006	0·004	1·06	265	1	1	1	1	3
bajra variety (b) . . .	3·62	0·006	0·004	0·46	115	3	1	1	1	3
ragi	1·67	0·005	0·005	1·14	228	4	1	1	1	3
gram and peas . . .	4·75	0·070	0·063	0·99	16	3	1	1	2	4
pigeonpea	2·00	0·012	0·010	1·05	105	3	1	1	1	3
other pulses (c) . . .	5·00	0·015	0·012	0·80	67	3	1	1	1	3
groundnut	4·50	0·120	0·120	1·20	10	3	1	2	2	5
brassicas	2·67	0·005	0·005	0·75	150	3	1	1	1	3
seasamum . . .	2·00	0·005	0·003	0·48	160	3	1	1	1	3

linseed . . .	1·30	0·015	0·012	0·38	32	4	1	1	2	4
other oil crops (c). . .	3·75	0·012	0·010	0·47	47	3	1	1	2	4
cotton	4·60	0·020	0·020	0·51	25	1	1	1	2	4
jute	1·00	0·010	0·005	0·54	108	2	1	1	1	3
fodder (d) . . .	6·60	0·060	0·008	0·42	53	4	1	1	1	3
total . .	104·73	..	..	..	..	..	..	..	..	..

NOTES :—

(a) Yield relates to paddy— not rice.

(b) Proportion of area between hybrids and varieties has been kept as 50:50.

(c) Seed rate and yield are assumed so as to be applicable to majority.

(d) Calculated for jowar.

(e) Multiplication stages are fixed as follows :

Multiplication ratio	stages
15 or less	5
16—50	4
51 or more	3

(f) The period considered for fixing yield is 25 years between 1976 and 2000 A.D. The yields in 1976 approximate to the present experience with regard to the performance of seed crops. The yields for 1985 are fixed proportionate to the difference between the rates at present and in 2000 A.D.

APPENDIX 47.1 (contd.)

Statement IV : Area and Production of Seed Crops in 1985
(Calculated on the basis of Statement III)

Area = hectares
Production = tonnes

Crop	Breeder		Foundation		Certified		Total	
	Area	Production	Area	Production	Area	Production	Area	Production
paddy	5·0	15·9	531·2	1,683·9	56,309·1	178,499·8	56,845·3	180,199·6
wheat	2·3	6·5	85·5	240·3	120,269·1	337,956·2	120,356·9	338,203·0
barley	3·4	5·7	77·6	131·1	42,835·1	72,391·3	42,916·1	72,528·1
maize hybrid	0·6	1·3	95·2	212·3	16,278·0	36,299·9	16,373·8	36,513·5
maize variety	1·7	1·8	137·9	147·6	11,308·4	12,100·0	11,448·0	12,249·4
jowar hybrid	2·6	2·6	316·0	312·8	39,191·9	38,800·0	39,510·5	39,115·4
jowar variety	5·9	3·1	382·6	198·9	24,871·7	12,933·3	25,260·2	13,135·3
bajra hybrid	0·3	0·3	77·3	81·9	20,490·6	21,720·0	20,568·2	21,802·2
bajra variety	1·2	0·6	136·9	63·0	15,739·1	7,240·0	15,877.2	7,303·6
ragi	0·03	0·03	8·0	9·1	1831·1	2,087·5	1,839·13	2,096·63
gram and peas	27·3	27·0	437·3	432·9	118,949·9	117,760·4	119,414·5	118,220·3
pigeonpea	0·7	0·7	72·6	76·2	7,619·0	7,999·9	7,692·3	8,076·8
other pulses	7·0	5·6	466·4	373·1	31,250·0	25,000·0	31,723·4	25,378·7
groundnut	15·0	18·0	1,650·0	1,980·0	165,000·0	198,000·0	166,665·0	199,998·0
brassicas	0·3	0·2	39·5	29·6	5,933·3	4,450·0	5,973·1	4,479·8
sesamum	0·3	0·1	43·4	20·8	6,994·4	3,333·3	6,988·1	3,354·2
linseed	0·4	0·2	12·4	4·7	13,121·3	4,986.1	13,134·1	4,991·0
other oilcrops	0·3	0·1	14·4	6·8	32,593·9	14,319·1	32,608·6	15,326·0
cotton	11·5	5·9	288·6	174·2	187,607·9	95,680·0	187,908·0	95,833·1
jute	0·8	0·4	85·7	46·3	9,259·3	5,000·0	9,345·8	5,046·7
fodder	83·9	35·2	4,447·4	1,867·9	235,714·3	99,000·0	240,245·6	100,903·1
total	170·53	131·23	9,405·9	8,066·4	1,163,117·4	1,296,556·8	1,172,693·83	1,304,754.43

48

FERTILISERS AND MANURES

1. ROLE OF FERTILISERS IN CROP PRODUCTION

Introduction

48.1.1 Addition of plant nutrients in the form of fertilisers constitutes an essential step in agricultural production. Because of the narrow land-man ratio which would get still narrower in coming years, the only hopeful means of supplying needs of agricultural produce would be by rasing the productivity level. One of the important inputs for achieving this objective is the fertiliser. Plant nutrients, consisting of major, secondary and microelements, have certain specific functions to perform in the plant and should be available in a balanced manner, otherwise the full benefits of each or all of them would not be achieved. The forms, chemical as well as physical, in which nutrients are to be applied to the soil determine not only their availability but also the use efficiency of the fertilisers containing them. The maintenance of quality of fertilisers in the chain of distribution is equally important. The fertiliser dosages are based on field experiments, and depend on crop variety, water availability, soil characteristics and management practices. Relatively inexpensive soil tests enable considerable economy of fertiliser use. Fertilisers attain optimum efficiency under favourable soil conditions for which suitable amendments are required and the soils are to be provided with adequate organic matter. In addition, organic manures and compost derived from plant residues and agricultural wastes and byproducts may provide plant nutrients. These and some related problems are delt with in this chapter.

Fertiliser Consumption

48.1.2 With the initiation of agricultural research in India and reorganisation of the Agriculture Department in 1905, considerable stress was laid on soil study and soil conditions contributing to crop growth. It was established that Indian soils, in general, were deficient in plant food materials and attention was drawn to problems arising

from this deficiency. The importance of the use of chemical fertilisers for the production of foodgrains and other crops was recorded, not without some amount of reservation, in the Report of the Royal Commission on Agriculture (RCA) 1928 in the following words :

> "It is hardly necessary to point out that the use of nitrogenous or other artificial fertilisers is not profitable in all conditions. Where crop production is limited by a small rainfall, the annual additions of combined nitrogen to the soil as the result of natural processes may be sufficient to meet the needs of a crop the outtern of which is limited by the moisture available."

The above contention may be valid so long as the yield of crops per unit of land is low and the demand of crops is satisfied by the nutrients present in the soil and those made available through natural recuperation processes.

48.1.3 It has been the experience throughout the world that increased agricultural production is related to increased consumption of fertilisers. Some data on fertiliser consumption and foodgrains production in India are shown in Table 48.1.

TABLE 48.1

Consumption of Total Nutrient ($N+P_2O_5+K_2O$) and Foodgrains Production

(million tonnes)

Year	Fertiliser consumption[1]	Foodgrains production[2]
1964-65	0·77	89·36
1965-66	0·78	72·35
1966-67	1·10	74·23
1967-68	1·54	95·05
1968-69	1·76	94·01
1969-70	1·98	99·50
1970-71	2·26	108·42
1971-72	2·66	105·17
1972-73	2·77	97·03
1973-74	2·84	103·61

Increasing trends of fertiliser consumption and foodgrains production are no doubt noticeable, but a one-to-one correlation is not observed. This is most probably due to the fact that fertilisers are not exclusively

[1]. Data obtained from Ministry of Agriculture and Irrigation, Government of India (Fertiliser Division).

[2]. Estimates of Area and Production of Principal Crops in India 1973-74. Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation.

used for foodgrains production. Moreover, some increase in production is evidently caused by increased areas under cultivation and irrigation. Of the other factors influencing the correlation in the domain of rainfed agriculture, climatic factors, especially rainfall distribution, seem to be the most important. It appears that following the introduction of the high yielding varieties of cereals, a higher proportion of fertilisers was diverted to their production. Even though the consumption of fertilisers in India shows an upward trend, the total amounts of nitrogen, phosphorus and potassium (NPK) consumed per capita and per hectare of agricultural land are, by comparison with other countries, still very low (Table 48.2).

TABLE 48·2

Consumption of Fertilisers per Hectare of Agricultural Land and per Capita[1]

Country	NPK/ha of agricultural land (kg)	NPK/capita (kg)
China (People's Republic)	15	6
France	150	97
GDR	255	101
India	15	5
Israel	49	20
Italy	82	27
Japan	332	20
Netherlands	283	46
Pakistan	11	4
USSR	17	43
W. Germany	245	56

Calculated on the basis of irrigated agriculture, the disparities may not appear as wide as seen in the table.

1. Fertiliser Statistics, Fertiliser Association of India, 1973-74. pp III-9-10.

TABLE 48·3

Projected Population, Area and Production of Foodgrains

Item	Projections			
	1971		1985	2000 AD
population (million)*	551		725	935
foodgrains requirement (human and non-human) (million tonnes)	108	low	150	205
		high	163	225
supply (million tonnes)	108	low	150	230
		high	164	
per capita availability of arable land (ha)	0·29		0·22	0·17
yield per hectare (kg)	872	low	1,180	1,870
		high	1,290	

*As on 1st July of respective years.

Enhanced Foodgrains Production Per Unit Area

48.1.4 Foodgrains production at present accounts for a large bulk of the fertilisers consumed in the country. This is going to be so in future as well. From our projected foodgrains requirements to feed the growing population as given in Table 48.3, it is evident that within a period of 25 years, the foodgrains requirements for the projected population around 2000 AD would be more than double. Only marginal increase in area for cultivation may be possible by providing irrigation facilities in arid areas and reclaiming some saline, alkaline and waterlogged areas and ravine lands. Of course, the water resources of the country are large and tapping them for agricultural use might help in increasing the gross cultivated areas. For attaining more than two-fold increase in production during the next 25 years, it would be necessary to improve the per unit area yield by various intensive agricultural methods and taking recourse to modern technology. As the percentage of land under arable use in India is already very high, it is reasonable not to extend it further. There should preferably be a tendency to gradually reduce the area as the yield per unit area of land increases. Maintenance of ecological balance is also to be taken into consideration.

Increasing Pressure on Land

48.1.5 Based on the existing and projected data on population, the per capita arable land works out as follows :

1970-71	0·28 ha
1985	0·22 ha
2000 AD	0·17 ha

It would thus be seen that there would be a continuous pressure developing on agricultural land. By comparison with some other countries of the world, India does not appear to be in an unfavourable position (Table 48.4).

TABLE 48·4

Per Capita Arable Land in different Countries (1970-71)[1]

Country	ha/capita
Belgium	0·09
France	0·38
India	0·28
Italy	0·28
Japan	0·05
Mexico	0·47
Pakistan	0·22
UAR	0·09
UK	0·13
USA	0·86

1. 1974, Indian Agriculture in Brief; Thirteenth Edition, DES.

Not only the demand for land for arable use is growing but, with the developing economy, the demand on land for civic uses, industries, roads, rural housing etc., is ever increasing. It can, thus, be easily realised that the pressure on land in the coming decades would be tremendous.

48.1.6 New lands for agricultural use being limited the solution lies in increasing the per unit area productivity by modernising agriculture with the help of technology. By taking recourse to multiple cropping programmes utilising high yielding varieties of crops, and necessary inputs including fertilisers, appreciable increase in production per unit area has become possible. From the yield data given in Table 48.5 a welcome trend is noticeable of increases in the yield of cereals from 1967-68 to 1973-74. Even then the yield per hectare of cereals in India is one of the lowest in the world.

TABLE 48·5

Yield of Total Cereals[2]

Year	Yield (kg/ha)
1967-68	840
1968-69	843
1969-70	865
1970-71	949
1971-72	936
1972-73	886
1973-74	909

2. Estimates of area and production of principal crops, 1973-74. Directorate of Economics and Statistics, ministry of Agriculture and Irrigation.

The world average per hectare yield (1,701 kg)[1] of cereals is much higher than India's. Japan leads all other countries in per hectare yield (3,106 kg) of cereals. These figures suggest that there is ample scope for increasing India's cereals productivity. By means of careful field experiments on scientific lines, one can get a fair idea of the attainable productivity potential. The National Demonstration Trials are aimed at demonstrating the efficiency of the new agricultural technology on cultivators' fields for maximising agricultural production. The results obtained so far are encouraging. The data given in Table 48.6 indicate the production potential of crops which are grown in various agroclimatic regions. Even taking into account the decreasing values during the three years of study recorded here the yields are nearly 4-6 times the average. Similar results have been obtained under the All India Coordinated Agronomic Experiments Scheme. A more intensive use of lands is possible by adopting a suitable scheme of multiple cropping as the data in Table 48.7 show.

TABLE 48.6

Mean Yields (q/ha) obtained under National Demonstration Trials

Crop	1968-69	1969-70	1970-71
paddy	59·5	56·9	56·1
wheat	40·0	40·7	..
bajra	33·0	32·4	30·7
maize	43·3	42·4	38·1
jowar	46·6	35·9	35·8

TABLE 48.7

Yield in tonnes/ha/year of multiple Crops under national Demonstration Trials

Crop rotation	Average yield in tonnes/ha/year		
	1967-68	1968-69	1969-70
rice-rice	10·5	9·4	10·5
peral millet-wheat	7·9	7·7	7·2
sorghum-wheat	6·5	8·1	8·0
rice-wheat	10·7	12·6	..
rice-rice-rice	13·3	15·4	13·7
jute-rice-wheat			
grain	9·9	10·3	10·1
fibre	2·1	2·1	1·3

[1] Production Year Book, FAO, 1970.

One should not, however, lose sight of the fact that multiple cropping (specially more than two crops) requires a high degree of tight scheduling of operations and sophistication to which none but a few progressive farmers would be able to address themselves by taking recourse to mechanisation, even if other inputs like water, fertilisers and pesticides are available.

48.1.7 The data presented above show the tremendous possibility of raising the unit area productivity provided the inputs of production are made available in adequate measure and proper management practices are followed. It must be emphasised that highly favourable conditions attainable in the trials, namely, high doses of fertilisers and necessary irrigation facilities can hardly be assured except on a limited scale, because of the constraints imposed by lack of adequate supply of fertilisers and water. The production potentials are, no doubt, eye-openers to future prospects in agriculture. It should be remembered that irrigation facilities are at present available to only 20 per cent of the cultivated area. The average unit area productivity as projected during 1985 and 2000 AD will largely depend on yields of crops under dryland or rainfed cultivation. Researches on dryland farming under an ICAR coordinated scheme are going on for some time. The yield trends obtained both in research plots and cultivators' fields give sufficient reason for optimism for higher yields than the present. Experiments have consistently shown economic returns even under rainfed conditions, provided the choice of varieties and quantity, method and time of application of fertilisers are made judiciously.[1]

48.1.8 It would not be out of place to focus attention on some of the relevant factors of world fertiliser production trends, which registered several ups and downs, especially in the sixties and early seventies. World production grew from 1.9 million tonnes in 1905 to 27.9 million tonnes in 1959-60. During the sixties the developed countries recorded a fertiliser production growth rate of 8 per cent and the developing countries a rate of 14 per cent. But in spite of a higher growth rate, the latter were in short supply because of large demand. The growth rates of consumption for the developed and the developing countries respectively were 7.5 and 14 per cent. As a result of high and growing demand, the early sixties saw fresh investments in fertiliser production. Some oil companies also started fertiliser manufacture, so much so that production ran faster than demand, leading to fall in prices and shut-down and curtailment of production by some companies. The demand of developing countries, however, went on increasing unabated, unmatched by production. Im-

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[1] Kanwar, J. S. 1972. Proc. Fertiliser Association of India. Seminar on Fertilisers in India in Seventies, P.II-2.

port became imperative causing rise in price in world market, but the developing countries had to depend on the marginal surplus in world market, which is usually no more than 5 per cent. The precariousness of the situation, therefore, lies in the fact that the 10-15 per cent compound rate of growth of consumption in the developing countries has to be met from the surplus of 5 per cent. in world market. Consequently, indigenous production has to be speeded up. But apart from technological difficulties and bottlenecks the developing countries have to put up with wide fluctuations in fertiliser demand because of the occurrence of bad and good years, which cannot be normally accommodated in production schedule.

2 PLANT NUTRIENTS

48.2.1 The relative amounts and forms of the major, secondary and microelements* present in soils are dependent to a large extent on the soil forming factors and their reactions and interactions, and hence on the prevailing soil types. When added from outside as fertilisers and manures they react with the soil constituents, thereby altering their relative proportions and forms depending on the chemical, physical and microbiological conditions of the soil.

Removal of Nutrients from Soils by Crops

48.2.2 The amount of nutrients removed by crops varies widely depending on the species and variety of plants, yields of grain and straw, moisture availability, soil reaction and other environmental conditions under which plants are grown. From an analysis of straw and grain it is easy to calculate the extent to which the soil gets depleted of nutrients by raising the various crops, and to what extent replenishment would be necessary. These calculations suggest that production of foodgrain and nonfoodgrain crops during 1970-71 resulted in the removal of about 12 million tonnes of nutrients ($N+P_2O_5+K_2O$) in the ratio of $N:P_2O_5 : K_2O=1:0.4 : 1.6$. For the projected production of foodgrains and nonfoodgrain crops during say, 1980-81 the depletion of nutrients is likely to be 18 million tonnes (see Appendices 48.1 to 48.3). In comparision to what are added in the form of fertilisers, the quantities removed by crops are staggering. This

*The major nutrients are nitrogen, phosphorus and potassium; secondary nutrients are calcium, magnesium and sulphur and the micronutrients are boron, chlorine, copper, iron, manganese, molybdenum and zinc.

phenomenon is perhaps sufficiently convincing to put the best efforts at recycling resources and returning wastes to field.

Natural Recuperation

48.2.3 The RCA (1928) observed, "Although but little of the nitrogen removed is returned to the soil in the form of manure, there is no definite evidence that the cropping values of Indian soils are diminishing. That they are maintained at a low but stable level of fertility as a result of large increments of nitrogen which accrue from natural recuperation processes in the soil has been established by work done in all provinces and qualitative estimates of these increments have been made in Bombay, the Central Provinces and the Punjab". The RCA recommended conduct of further research to determine with greater precision the causes involved in such recuperative processes under varying conditions of soil and rainfall. Following this recommondation considerable stress was laid on researches involving the natural recuperative processes in soils in subsequent years and it was established that a number of microorganisms, both symbiotic and nonsymbiotic, were involved in the process. In India, green manuring with leguminous crops has been practised from olden days and constitutes an important feature in crop rotation and mixed cropping. Various estimates have been made as to the amount of nitrogen added to the soil by root-nodule bacteria in symbiosis with the host plant and these figures vary from 30 to 400 kg per hectare per crop per season depending on plant type and efficiency of the associated nodule bacteria. More recent studies have revealed the usefulness of inoculation of a number of leguminous crops grown in India by certain strains of *Rhizobium*. Application of phosphate further enhances the growth of *Rhizobium* as well as of legumes.

48.2.4 A number of free living organisms, e.g., *Azotobacter* and *Beijerinckia*, inhabiting the soil are capable of fixing, nonsymbiotically, atmospheric nitrogen. Under aerobic conditions. *Azotobacter* fixes a substantial amount of nitrogen provided energy material in readily available form exists for its growth and multiplication. Apart from nitrogen, these bacteria are known to release growth promoting substances which enhance seed germination, and ensure better and more vigorous stand of plants, thereby indirectly increasing the yield. There is considerable scope of finding newer and more efficient organisms capable of nitrogen fixation.

48.2.5 In India the monsoonic climate keeps extensive area in various parts of the country in waterlogged or anaerobic conditions, where rice is the predominant crop. Rice has been grown in such

areas year after year without any significant decrease in yield. The main biological consequence of waterlogging, as prevalent in rice fields, is the growth of several forms of algae. Some of these, especially the blue-green algae, are known to fix atmospheric nitrogen. The different algae vary in their capacity to fix nitrogen, ranging from 3.6 to 14.5 mg/100 ml. Blue-green algae have added advantages, in that they can solubilise slightly soluble phoshates in soil, and supply growth promoting substances. The yield increase by algal fertilisation is observed even in the case of high yielding varieties of paddy, which are highly nitrogen responsive and usually heavily fertilised with nitrogen. When superimposed on added nitrogenous fertilisers, the differential increase due to algal fertilisers is much greater than nitrogen fertilisers alone and more profitable.

48.2.6 For the purpose of using algal materials as fertiliser aids, methods of growing these in bulk and keeping them in a viable state have been developed. Of these, growing algae in sewage or urban effluent waters would not only produce biofertilisers but also serve the purpose of reclaiming sewage water for irrigation. Because of the presence of nitrogen in sewage water the growth of algae is more luxuriant than in rice fields.

48.2.7 Nitrogen is a fugitive constituent of the soil and is subject to a variety of transformations. Because of the existence of a well established cyclic operation involving the different transformations, it is possible to make a fairly accurate estimate of the gain and loss of nitrogen. The loss from the soil is mainly due to uptake by vegetation, leaching and denitrification. The gain is through rain water, symbiotic process in root nodules of leguminous plants, and free living nitrogen fixing organisms. Assuming that the gain through rain water is compensated by the loss due to leaching and denitrification, the net gain is the result of what is added by legumes and bacteria. A rough calculation suggests that these two sources respectively contribute annually about 1.0 and 0.15 million tonnes of nitrogen to the 24 million hectares of land under legumes. Compared with what is now being added in the form of chemical fertilisers, namely, 1.8 million tonnes, the amount so added is indeed substantial. The *Rhizobium* spp. in fixing this amount of nitrogen function under a variety of adverse conditions. There is considerable room for a severalfold increase in their efficiency, which involves selecting superior strains and offering optimum conditions in the soil. It seems possible not only to breed new strains or species of *Rhizobium* but also a new genus of nitrogen fixing bacterium capable of infecting nonleguminous plants. If such a possibility materialises the cereals may easily satisfy part of their nitrogen requirements through this process.

48.2.8 Of the nonsymbiotic processes responsible for gain of nitrogen in soil, the various blue-green algae and the free living aerobic bacteria like *Azotobacter* and *Beijerinckia* deserve mention. The efficiency of blue-green algae to enrich rice soils has been mentioned earlier. The free living bacteria suffer from the handicap that they are less active in presence of high doses of nitrogenous fertilisers. Unless fast growing and highly efficient strains of *Azotobacter* are evolved, their contribution to the soil growing high yielding varieties of crops would not be appreciable. There are, however, a few species of *Azotobacter* present in the rhizosphere of cereals and nonleguminous plants, a suitable suspension of which reduces the nitrogen requirements of rice, ragi, cotton and tomato by 20 to 40 per cent. For this purpose either the seeds are pretreated, or seedlings dipped in the suspension of the bacterial culture, or it is added to the soil. The potentialities of these observations seem to be enormous and fundamental studies are called for to explore them.

48.2.9 Unlike nitrogen, the other two major nutrients, namely, phosphorus and potassium, have to be obtained from soil reserve itself. The tapping of this source requires a knowledge of the soil conditions, namely, pH, moisture content, nature of clay minerals, forms of elements and the nature of microorganisms phosphobacteria are autotraphic phosphorus solubilising bacteria by the inoculation of which a greater availability of soil phosphorus may be ensured.

Fertilisers in the Farming System

48.2.10 Both mineral and organic matters of the soil are sources of plant nutrients. But as the available plant nutrients which ordinarily constitute a small part of the total amount present in the soil are often inadequate for growing crops, these require supplementation from outside sources. They are: (a) chemical fertilisers which are ultimately responsible for adding organic matter to the soil in the form of plant roots and residues, (b) farmyard manure, compost, night soil, organic wastes, etc. which, by their decomposition, bring about microbiological activities and increase soil humus and (c) soil amendments which are primarily used for correction of unfavourable soil conditions such as soil acidity and alkanity, poor soil structure etc. Lime, dolomite and limestone are ordinarily used to correct acidity. They also supply available calcium and magnesium which are secondary nutrients. Gypsum or other sulphur compounds which are used for correction of alkaline condition in the soil also supply calcium and sulphur. Some of the chemicals used as pesticides, weedicides, etc. may, in addition, act as growth regulating or growth promoting factors.

48.2.11 The indigenous varieties of crops with low yield potential which were traditionally cultivated, had low nutritional requirement. But it should be noted that even these old varieties could be made to yield somewhat higher by the use of fertilisers and water. The introduction of high yielding varieties has changed the concept of farming system, which aims at optimisation of yield. The high yielding varieties have exacting nutrient requirement which the soil reserve and natural recuperative processes can hardly cope with. For success in modernised farming, an efficient and balanced (cf. para 48.2.15) use of fertilisers and manures is imperative. The experience in the IADP districts has shown that the trend is for applying more of phosphates along with nitrogen, instead of nitrogen alone which was in vogue earlier. In the package district of Ludhiana there has been reversal in the schedule of fertilisation and more of phosphates are in demand. The diversity of soils of India coupled with the diversity of climate changes the farming system which may be simple or exceedingly complex depending on the economy of the community and skill and resources of the cultivator. Whatever may be the soil-water complex, there should be a well planned cropping system providing nutrients for growing crops in sequence or rotation in order to build up soils to a high state of productivity and maintain it there. For soils affected with acidity, salinity and alkalinity etc., reclamatory measures are required, to be followed by growing crops with adequate fertilisation. It would, therefore, be seen that in the farming system of the country, the dominant role of fertilisers has come to stay.

Need for Nutrient Balance

48.2.12 Plant nutrients aid as well as compete with one another in the soil while entering the roots of the plant. Their modes of action and interaction are usually complex. Healthy and normal plants are found to have nutrients in certain ratios which vary within somewhat narrow limits. They are said to have a proper balance. Many cases of imbalance in nutrition have been recorded with the help of characteristic visual symptoms of such imbalance.

48.2.13 Plants can grow well under a rather wide range of conditions. Crop varieties with low yield potential rarely show deficiency symptoms in a great variety of soils which furnish the nutrients at a relatively low rate. If the cropping conditions change towards yield increase, e.g., from dry to assured irrigated farming, or by introduction of high yielding varieties responsive to heavy fertilisation, the soils good under the above conditions show up nutritional disorder in crops under the changed condition. The IADP experience has revealed that for the attainment of maximum potential yield balanced

nutrition is of utmost importance. With the initiation of IADP programme, the farmers impressed by the good vegetative growth of crops have gone all out for nitrogenous fertilisers. As a result the balanced availability of fertilisers has been adversely affected. With the IADP programme aiming at optimisation of crop yields by the use of new varieties of cereal crops, the trend has been towards balanced use of fertilisers by incorporation of more phosphate with nitrogen. Nitrogen alone does not give the desired response. In other areas also, the trend for balancing the fertilisers is gradually becoming evident. Many soils are deficient in two or more nutrients. In such cases, the addition of one nutrient only may produce little or no increase in yield, but addition of all the deficient nutrients produces a large increase in yield.

48.2.14 Under the All India Coordinated Agronomic Experiments Scheme it has been found that the interaction between nitrogen and phosphorus is significant at a number of centres and was generally positive, resulting in higher yields being obtained with combined application of nitrogen and phosphorus. Not only higher yields but a more effective utilisation of both nitrogen and phosphorus is assured. In cultivators' field trials also significant effects of interaction have been observed; positive results were obtained in 8 out of 15 districts for rice and 16 out of 19 districts for wheat. Sometimes, however, for reasons not yet fully understood, the effect of adding all the nutrients together may be less than the sum of the individual effects and hence the interaction is negative. It is obviously a matter of practical importance to determine by experiments the responses of crops to fertilisers on particular soil types. Under the high yielding varieties programme, where high doses of major nutrients are being applied, conditions have arisen in which zinc has become a limiting factor. Thus, fertiliser practices need revision to meet changing conditions. Deficiency of other elements may similarly arise and should be watched and studied.

48.2.15 The essentiality of N,P and K as the major plant nutrients has long been recognised. Because of the fugitive nature of nitrogen under tropical conditions and the proverbially low content of nitrogen of Indian soils attention was initially directed to demonstrate the use of this element in most of the fertiliser experiments. The results were indeed spectacular, there being an excellent response to nitrogen application but gradually it became apparent that nitrogen alone is unable to sustain a balanced growth of plants, particularly those producing grains or fruits. The need of adding phosphorus along with nitrogen was felt when it was shown that NP interaction was highly positive, and a combination of the two had a marked influence on the efficiency of their assimilation by the plant. Potassium once thought to be

present in sufficient quantity in Indian soils, has been showing excellent response by the high yielding varieties of cereal crops, sugarcane and tubers like potato. Good response to potassium has been observed even in the case of traditional varieties especially in high rainfall areas, where soils get drastically depleted of all plant nutrients. Sometimes, K shows positive interaction with N and P. As a result of these experimental findings and demonstrations there is a strong awareness about the balance that ought to prevail in respect of the three elements.

48.2.16 Assuming that the countries which have a well established agricultural pattern and a complete awareness about the use of fertilisers have achieved a balance amongst the three major nutrient elements through years of experience, the proportions in which the fertilisers containing them are consumed should provide a sufficiently valid measure of the balance required for good agriculture. One should not lose sight of the fact that the ratios are often misleading in the sense that they may ensure optimum balance, but not the optimum yields, which depends, in addition, on the actual amounts of the fertilisers added.

48.2.17 One should at the same time be cognisant of the fallacies involved in arguments such as the above. The nutrient balance which has direct influence on the metabolic activity of the plant prevails in the body of the plant itself. This balance or relative proportions of N, P and K in the plant body may be related, in a complex manner, with those in the soil or fertilisers applied but not necessarily in the same proportions, it being well known that the availability of added fertilisers is not in the same proportions as they are applied to the soil. In that case, the comparision of the equivalence of nutrient ratios within the plant with the consumption ratios is farfetched, unless some *ad hoc* assumptions are made. In spite of the fallacy mentioned above, attempts have been made to arrive at a measure of nutrient balance by means of the consumption ratios of the NPK fertilisers. Peculiarly enough, the consumption ratios are customarily calculated in terms of $N:P_2O_5:K_2O$, each expressed in tonnes. In the plant body, it is known that N, P and K are absorbed mostly in the form of NO_3^- or NH_4^+ $H_2PO_4^-$ and K^+ ions respectively. Consequently, the consumption ratios will have little meaning unless calculated in terms of the ionic forms in which the nutrients are taken up from the fertilisers or else we may follow the internationally accepted N:P:K (atomic) for comparison.

48.2.18 It may be of interest to calculate the nutrient ratios in growing plants and compare them with the consumption ratios. If the critical concentrations, which are just enough for growth, of these ionic species in the plant body are considered, the ratios, converted into $N:P_2O_5:K_2O$, are far from the consumption ratios supposed to

maintain nutrient balance. Thus, for wheat the critical ratio is 1:1.7:0.006 whereas for maize it is 1:0.007:0.0002, which are off several orders of magnitude. The final fallacy refers to the completely different utilisation/consumption ratio of fertilisers under tropical conditions as compared to temperate conditions. It is common knowledge that nitrogen utilisation is much less in tropical countries than under temperate conditions, a good proportion being lost in the former by leaching and denitrification. Hence, the consumption should be proportionately more, and therefore, N:P ratio would appear wider.

48.2.19 Instead of the consumption ratios we may preferably consider for comparison the nutrient ratios (also as $N:P_2O_5:K_2O$) in the recommended doses for various crops. It is noticed that the latter are much narrower than what is given by the former. This shows that if the recommended doses could be uniformly followed throughout the country, the consumption ratios would have compared favourably with those of the developed countries. The departure from the recommended doses is most often caused, among other factors, by non-availability of fertilisers, and not necessarily due to lack of awareness of the usefulness of balanced fertilisation. This awareness is indicated by the increasing proportions of phosphate, and to a small extent of potash, consumed over the years starting from 1965-66. Further observations on the efficacy of a balanced use of nitrogen and phosphorus have been made in section 7 while discussing the economics of fertiliser use.

3 ASSESSMENT OF FERTILISER REQUIREMENT

Methodology

48.3.1 In respect of planning agricultural production, the assessment of fertiliser requirement is crucial. Of the several possible approaches none is entirely free from uncertain assumptions. Nevertheless, some kind of assessment is imperative for the obvious purpose of matching production or supply with the demand. The methods that have scientific basis and at the same time lend themselves to comparatively straightforward calculation are the following :

(i) based on replenishment of nutrients removed by crops;
(ii) based on areas under crops and recommended doses; and
(iii) based on agricultural production demand and response rate of crops to addition of fertilisers.

The merits and limitations of each of the three approaches will be evident from the following discussion.

48.3.2 As regards (i), the quantity of nutrients stored in the soil is large in comparison to what is added in the form of fertilisers. That is the reason why the soil can sustain a base production unaided by fertilisers. The quantity removed by crops from a well fertilised soil is also considerable which can be determined by chemical analysis. It varies with the crop and soil conditions. If the quantity lost as a result of removal by crops is replenished the nutrient status of the soil is most likely to be regenerated. It should, however, be noted that the crops draw upon the soil as well as the fertiliser source for their nutrient requirement. Calculations given in Appendices 48.1 to 48.3 show, as already mentioned (Paragraph 48.2.2), that the total quantity of nutrients removed by crops is much greater than that consumed by plants or added as fertilisers. The data for several years are summarised in Table 48.8 and represented graphically in Fig. 48.1 which shows the variation in the ratios of fertilisers consumed to those removed by crops during 1960-61 to 1973-74. A close look at the data given in Table 48.8 suggests that even in 1960-61 where the added nutrients in the form of ($N+P_2O_5+K_2O$) fertilisers constituted no more than 5 per cent, the remaining 95 per cent requirement for foodgrains was provided by the soil. The corresponding amount, namely, 6.66 (=F−C) million tonnes of $N+P_2O_5+K_2O$, therefore, represents the capacity of the soil to supply nutrients at that point of time. As the production increases during 1960-61 to 1973-74 removal by crops also increases, part (roughly 10 to 30 per cent) of which is supplied by fertilisers, and the rest by the soil itself. A scrutiny of the F−C values over these years shows that they do not change much (6.24 to 7.33). It would be of interest to keep a watch on these values in successive years by elaborating a project on this subject. The amounts of nutrients removed by non-food crops (=T−F) vary from 2.60 to 3.16 million tonnes.

FIG. 48·1 (PARAGRAPH 48·3·2)

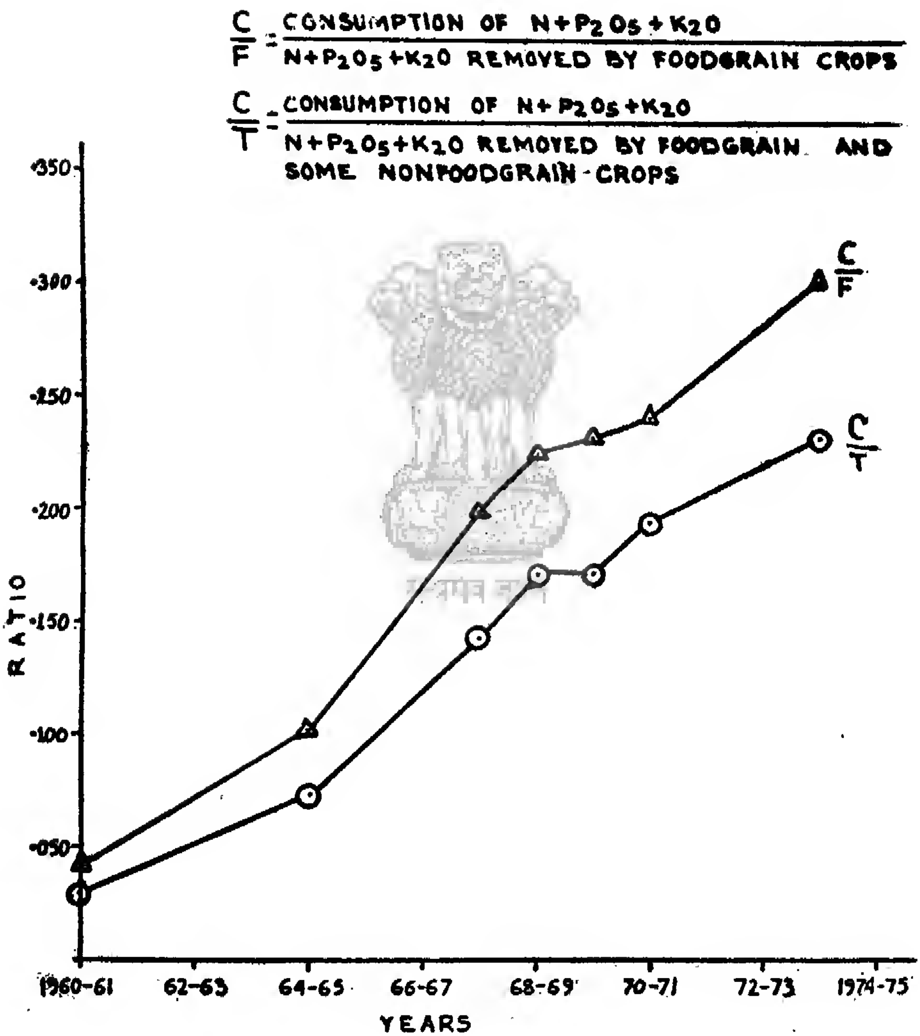

TABLE 48.8

Nutrients Removed by Crops and Nutrients Consumed and their Ratios

	1960—61				1964—65				1967—68			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
nutrients removed by foodgrain crops (F)	2.37	0.91	3.69	6.97	2.56	0.98	4.09	7.63	2.77	1.08	4.35	8.20
nutrients removed by foodgrain and non foodgrain crops (T)	3.03	1.35	5.14	9.57	3.42	1.50	5.64	10.67	3.56	1.58	5.88	11.02
fertiliser nutrients consumed (C)	0.21	0.07	0.03	0.31	0.55	0.15	0.07	0.77	1.03	0.34	0.17	1.54
$\frac{C}{F}$	0.089	0.077	0.008	0.044	0.215	0.153	0.017	0.101	0.372	0.315	0.039	0.18
$\frac{C}{T}$	0.068	0.051	0.005	0.032	0.161	0.100	0.012	0.072	0.289	0.215	0.029	0.14
F—C				6.66				6.86				6.66
T—F				2.60				3.04				2.82

TABLE 48.8

Nutrients Removed by Crops and Nutrients Consumed and Their Ratios

	1968-69				1969-70				1970-71				1973-74			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
F	2·68	1·07	4·25	8·00	2·84	1·14	4·54	8·52	3·33	1·24	5·02	9·59	3·12	1·18	4·88	9·18
T	3·42	1·49	5·72	10·63	3·67	1·64	6·14	11·45	4·16	1·69	6·53	12·38	4·02	1·69	6·63	12·34
C	1·21	0·38	0·17	1·76	1·36	0·41	0·21	1·98	1·48	0·54	0·24	2·26	1·83	0·65	0·36	2·84
$\frac{C}{F}$	0·451	0·355	0·040	0·220	0·479	0·360	0·046	0·232	0·44	0·44	0·044	0·24	0·587	0·551	0·074	0·309
$\frac{C}{T}$	0·354	0·255	0·030	0·166	0·371	0·259	0·034	0·173	0·36	0·32	0·037	0·183	0·455	0·385	0·543	0·230
F–C				6·24				6·24				7·33				6·34
T–F				2·63				2·93				2·79				3·16

This analysis gives added support to the suggestions made later in this report for recycling agricultural wastes. It will be further seen from these data and the graph that prior to the introduction of high yielding varieties of crops, i.e. 1966-67, nutrients added as fertilisers constituted only a small fraction of those removed by crops but the rate of consumption showed a steep rise from 1968-69 onwards with some slowing down in 1969-71. Even during the rising periods the fertiliser added to supply nutrients constituted on an average about 55 per cent N, 45 per cent P_2O_5, 5 per cent K_2O, and 25 per cent of total $N+P_2O_5+K_2O$ removed by crops. It is, of course, not necessary always to replenish the amount removed, bacause not all that is removed is lost. Some are returned as crop residue; some, originally unavailable or carried below root zone are converted into an available form or brought upto the root zone as a result of the crop rotation normally practised in any good farming operation. The quantities of nutrients removed serve, however, as a rough guide to what a crop needs at its utmost. Because of shortage of indigenous production of fertilisers, and somewhat faulty distribution, the consumption figures may not speak truthfully of the real demand, which appears to be higher. If, therefore, the demand is set at 60 per cent N, 50 per cent P_2O_5 and 10 per cent K_2O of the quantities of each removed from the soil, the total would come to 32 per cent or about one-third. Thus, for 1980-81, the nutrient removal by foodgrain crops has been calculated (cf. Appendix 48.3) as 4.17 N, 1.64 P_2O_5, 6.69 K_2O and a total of 12.5 million tonnes. The demand may, therefore, be set at 2.50 N, 0.82 P_2O_5, 0.67 K_2O, which add to 3.99 million tonnes, close to one-third of the total. The same yardstick may be used to calculate the combined fertiliser requirement of the foodgrain and non-foodgrain crops. Thus, by reference to the data given in Appendix 48.3 the 1980-81 figures for N, P_2O_5 and K_2O come out to be 3.41, 1.27 and 0.99 million tonnes respectively, which total 5.67, close to one-third of the total nutrients (18.12 million tonnes). Similar calculations may be performed to find out the fertiliser requirement of any future year, provided the targets of production of various crops are fixed. Assuming a production target of 150.3 million* tonnes of foodgrains for 1985, the fertiliser requirements have been calculated on the above basis. The nutrients removed by this targeted foodgrain production are 4.4, 1.7, 7.0 million tonnes of N, P_2O_5 and K_2O respectively, totalling 13.1 million tonnes. Taking, in addition, non-foodgrain crops into account, the amounts of nutrients removed come to 5.9, 2.6 and 10.3 million tonnes of N, P_2O_5 and K_2O respectively, totalling 18.8 million

* The targets of foodgrains production for 1985 and the programmes and inputs necessary for achieving these targets, using the production potential or yardstick approach, have already been discussed in Chapter 11 on Supply Possibilities.

tonnes. On the basis of the norms prescribed above, the quantities of fertilisers that will be required for achieving the targeted production of foodgrains and non-foodgrains during 1985 works out to 3.6, 1.3 and 1.1 million tonnes of N, P_2O_5 and K_2O respectively, totalling 6.0 million tonnes. Assuming that the consumption of fertiliser in 1985 will follow the earlier trends, the requirements of N, P_2O_5 and K_2O will be (from graph in Fig. 48.2) 3.6, 1.4 and 1.0 million tonnes respectively, totalling 6 million tonnes. This is the same as that calculated from nutrients removal data.

48.3.3 As regards (ii), the basic data required for the calculation are (a) area under various crops, high yielding as well as local varieties and areas irrigated and rainfed; and (b) the recommended fertiliser doses for each of the above conditions regarding crops and irrigation. The data in respect of (a) may not vary much when compiled from different sources, but there is a good deal of flexibility in the choice of the doses. Two sets of data have been compiled in Appendices 48.4 to 48.6 in which difference in the data on areas are negligible, but those on fertiliser doses are considerable, and all the differences obviously arise from the latter.

48.3.4 The data given in Appendix 48.5 are based on the assumption of the doses* of fertiliser for optimum production as have been recommended following fertiliser trials (Table 48.9).

* To be suitably modified in a multiple cropping schedule in order to take account of residual effects and crop rotation involving leguminous crops (cf. Paragraph 48.7.10).

TABLE 48·9

Fertiliser Doses Recommended for Crops

Crops	Doses in kg/ha for HYV			Doses in kg/ha of old local varieties		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
paddy	120	60	60	40(45)+	20(30)	20(30)
wheat	120	60	60	40(40)	20(25)	20(25)
maize	60	30	30	60	30	30
bajra	60	30	..	60	30	..
jowar	60	30	..	60	30	..
millets	60	30	..	60	30	..

Crops	Doses in kg/ha of local/old varieties		
	N	P_2O_5	K_2O
barley	40	20	..
ragi	30(90)	20(60)	..
other cereals	18	9	..
gram	10(15)	20(30)	..
arhar	10(15)	20(30)	..
sugarcane	80(500)	40(250)	40(250)
other foodcrops	16	8	..
oilseeds	30	22·5	..
cotton	30(60)	15(30)	25(30)
jute etc.	33	22·5	33
tea and coffee	134	89·6	123

+Figures in parenthesis are for irrigated areas.

The fertiliser requirements come out to be 9.35, 5.81 and 3.55 million tonnes of N, P_2O_5 and K_2O respectively, and a total of 18.71 million tonnes of $N+P_2O_5+K_2O$. These figures assume *per se* the full coverage of 1973-74 targeted areas for the high yielding varieties, and the application in full of the recommended doses of fertilisers for all the crops under all the envisaged agricultural conditions. Since we find that even in irrigated areas under high yielding varieties, the full doses are not applied by all the farmers, and that the fertiliser application is generally very poor under rainfed condition and with local varieties, the calculated estimates are likely to be much higher than the actuals. In fact, the provisional figures of consumption* of N, P_2O_5 and K_2O for 1973-74 are 1.83, 0.65 and 0.36 million tonnes respectively, the total being a mere 2.84 million tonnes, as against the calculated 18.71 million tonnes. The percentage consumptions are, therefore, N 20, P_2O_5 11 and K_2O 10, and 15 of the total.

48.3.5 The estimates may be scaled down either by assuming a much lower coverage of areas, or by assuming lower applied doses of fertilisers or both. On the basis of the quantity of fertiliser consumed during 1970-71 and the crop performance, the Ministry of Agriculture and Irrigation observed that the total doses of fertilisers ($N+P_2O_5+K_2O$) for the high yielding varieties of wheat, paddy, maize, jowar and bajra were 106, 106, 100, 60 and 60 kg/ha respectively.* In order to achieve a higher targeted production, these doses have been increased, following expert advice, to 140, 140, 120, 65 and 65 kg/ha respectively for the same crops. Appendix 48.6 gives the estimates, based on these assumptions, of the fertiliser requirements for 1978-79 as N 5.21, P_2O_5 2.19 and K_2O 1.10 million tonnes, or a total of 8.5 million tonnes ($N+P_2O_5+K_2O$) for foodgrain and non-foodgrain crops. If the trend of consumption, as has been observed during the year 1967-68 to 1973-74, is maintained (Fig. 48.2), the extrapolated estimates for 1978-79 ought to be respectively 2.61, 0.95 and 0.59 for N, P_2O_5 and K_2O and 4.24 million tonnes for $N+P_2O_5+K_2O$ against sum of individual N, P_2O_5 and K_2O values equalling 4.15 million tonnes. These extrapolated values are, therefore, 50, 41, 53 and 51 per cent for N, P_2O_5 and K_2O and $N+P_2O_5+K_2O$ respectively, i.e., nearly half of the estimated requirements for each.

48.3.6 While there is some amount of rationality in the calculations elaborated in (i) and (ii), the estimated requirements are far too large and appear unreal in the context of consumption trends. If, however, the demand is set at 60 per cent N, 50 per cent P_2O_5 and 60 per cent K_2O of the estimated requirements on the basis of scaled

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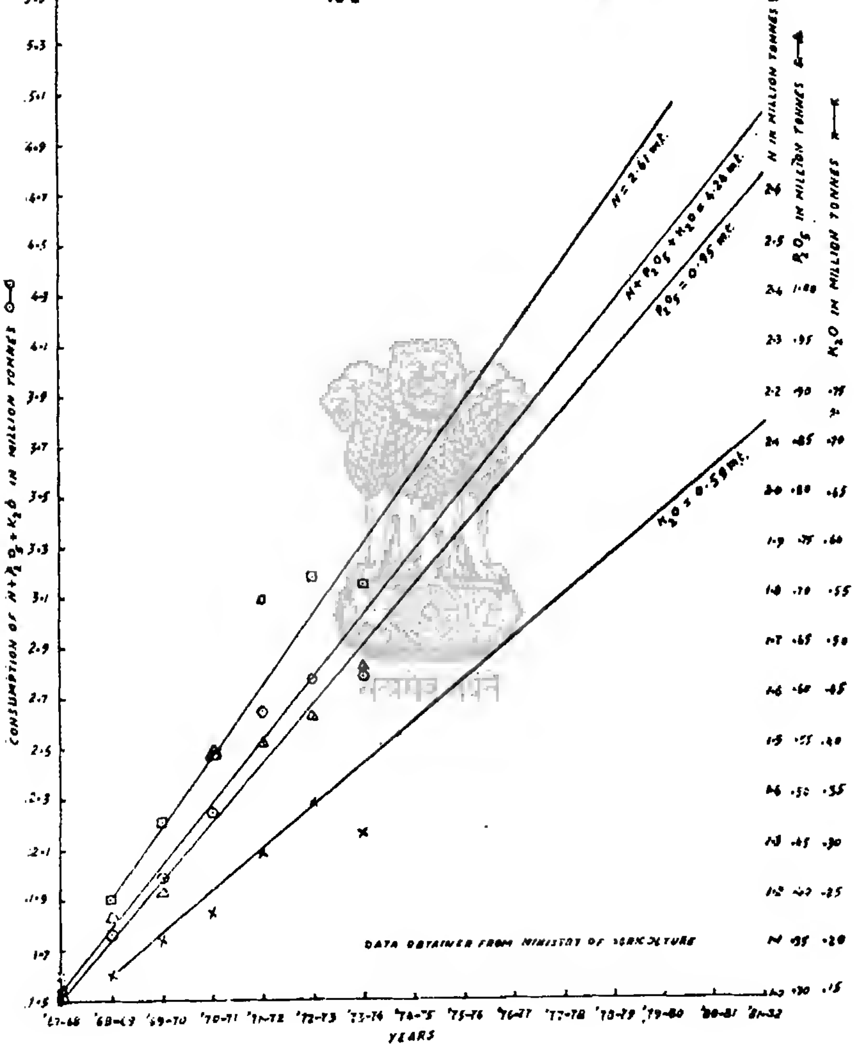
* Data obtained from the Union Ministry of Agriculture and Irrigation

FIG. 48·2 (PARAGRAPH 48·3·5)



down doses, it would appear to be a more practical target to achieve. The total of $N+P_2O_5+K_2O$ will accordingly come to 4.89 million tonnes, i.e. 57.5 per cent of the estimated quantity.

48.3.7 A similar calculation on the assumption of scaled down doses made for 1973-74 gives the figures as N 3.99, P_2O_5 1.57 and K_2O 0.70 totalling 6.26 million tonnes. A comparison with the data compiled in Appendix 48.7 shows the marked difference from the consumption (provisional) of fertilisers in 1973-74. In fact, quantities consumed are 46, 40, 44 and 44 per cent respectively of N, P_2O_5, K_2O and $N+P_2O_5+K_2O$ of the calculated values. Fiftyfive per cent of the calculated values would have been a reasonable target. That would make the estimates as 2.20, 0.81, 0.39 and 3.40 million tonnes respectively for N, P_2O_5, K_2O and $N+P_2O_5+K_2O$, which compare fairly well with the targets 2.19 and 0.67 million tonnes for N and P_2O_5 as was anticipated by the Ministry of Petroleum and Chemicals (vide our Interim Report on Fertiliser Distribution, p. 12). Estimates based on 55 per cent of the calculated values mentioned above, however, almost coincide, surprisingly enough, with the estimates made by the Fertiliser Association of India (FAI), namely, 2.2 N, 0.8 P_2O_5 and 0.4 K_2O[1]. The estimates by the FAI for 1978-79 appear to be unrealistically blown up and are closer to the Ministry's figures mentioned above. Here also a realistic estimate would be 55 per cent of the calculated values. Thus, for 1978-79 the estimates are 2.86 N, 1.21 P_2O_5 and 0.60 K_2O million tonnes, which fall in line with the extrapolated consumption trend, as mentioned earlier.

48.3.8 As regards (iii) viz., the calculation based on agricultural production demand and the general response rate of crops. i.e., the amount of additional produce obtained by the addition of a unit quantity of fertiliser is straightforward. The usual value for this rate is taken to be 10, meaning thereby that 1 tonne of NPK nutrients is going to give additional 10 tonnes of grains. In one set of calculations made by the Ministry of Agriculture and Irrigation, the value has been assumed to be 9 for high yielding varieties, and 6.5 for the local varieties of crops. The assumption of a low value of response rate leads to considerable increase of the fertiliser requirement.

48.3.9 Looking once again at the overall fertiliser consumption trends and comparing them with agricultural production, the realistic picture that emerges is quite different. For instance, if the figures for fertiliser consumption are plotted against those of agricultural production given in Table 48.10, the overall trend is unmistakeable.

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[1] Frt. News.1974, 19,58.

TABLE 48·10

Year to Year Variation of Response Rates

Year	n**	Fertiliser consumption (million tonnes)*** C	Food-grains production (million tonnes) P	Other* crops production (million tonnes) p^1	Total production+ (million tonnes) $P = p + p^1$	Response A**	Rates B**
1	2	3	4	5	6	7	8
1966-67 .	1	1·20	74·2	22·1	96·3	52·3	60·3
1967-68 .	2	1·60	95·1	25·3	120·4	13·8	7·5
1968-69 .	3	1·68	94·0	27·0	121·0	17·7	21·3
1969-70 .	4	1·99	99·5	28·1	127·6	46·8	54·2
1970-71 .	5	2·18	108·4	29·5	137·9	(—)7·6	—9·5
1971-72 .	6	2·60	105·2	28·7	133·9	..	..

*Other crops include oilseeds, sugarcane (gur), potato and cotton (kapas).

**$A = (P_{n+1} - P_n) / (C_{n+1} - C_n)$, $B = (P_{n+1} - P_n) / (C_{n+1} - C_n)$,

where n = 1,2,3,4 & 5 (of column 2).

***Data on consumption of fertilisers taken from E&S Directorate's Indian Agriculture in Brief 12th Edn. 1973.

+The additivity of production figures of diverse crops, brought to the same unit, in column 6 is justified insofar as these figures are meant to derive response rate, a biological factor common to all crops.

The individual response rates calculated from these data are given in the same table (columns 7 & 8). Because of the overall nature of the data, both on fertiliser consumption as well as production, the response rates so calculated show some abnormal variations, including negative values. If, however, the response rates are calculated from the slopes of the graphical plots (cf. Fig. 48.3) the abnormalities are smoothed out. The values obtained from the graph are 17 for foodgrain crops, and 23 for foodgrain crops plus four other crops, namely, oilseeds, sugarcane, potato and cotton. These values would mean that even for foodgrain crops the actual value realised in practice is nearly double that assumed by the Ministry of Agriculture and Irrigation. A much higher rate than the customary value of 10 signifies a better performance, which is surprising, but the graphs admit of no other interpretation. The observed rate, it should be noted, is due not only to fertilisers alone but also to other inputs, such as irrigation, improved seeds, plant protection measures, that are concomitant with higher fertiliser application. Lack of necessary data does not allow separation of the effect of each of these factors and thereby find but the exact role of fertilisers in agricultural production. It is also admitted that the data given in Table 48.1 refer to too few years

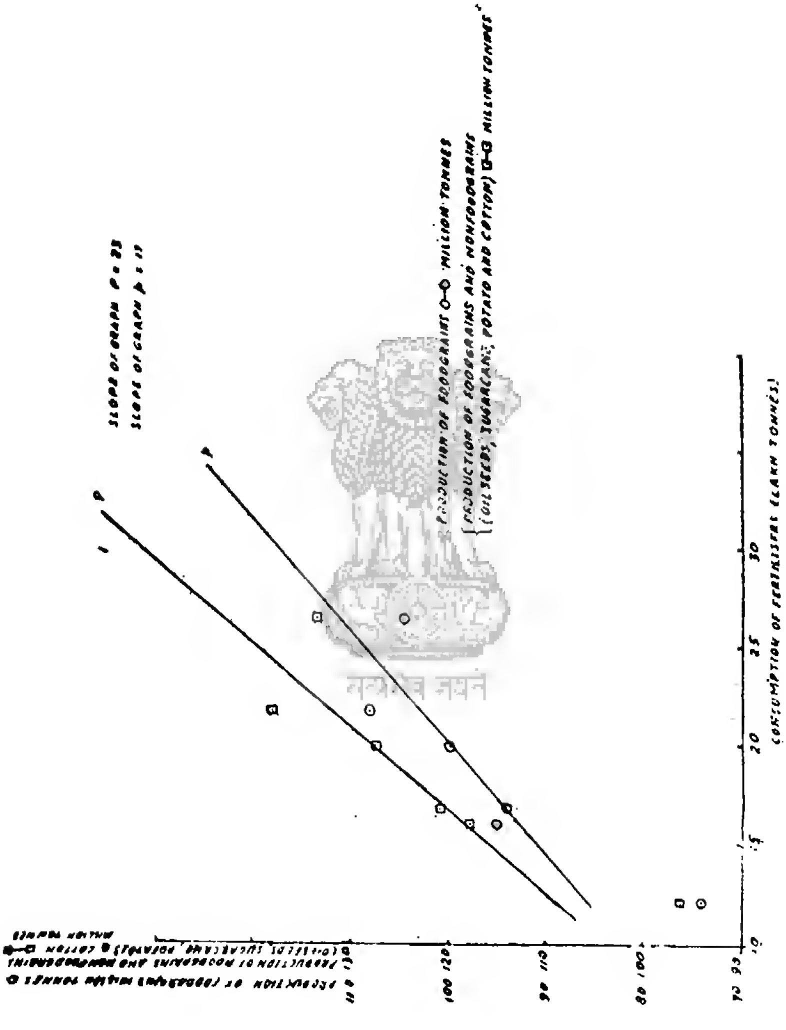

FIG. 48.3

(PARAGRAPH 48.3.9)

to enable a good estimate but these were the years when fertilisers had an impact on agricultural production. In spite of these limitations, a broad trend is indicated, and that is what these calculations have aimed at. Taking 1973-74 as the base, the additional production of 26 million tonnes of foodgrains during 1978-79, would require 1.53 million tonnes of additional NPK fertiliser, i.e. as total consumption of 2.84+1.53=4.37 million tonnes, which is, as expected, equal to the extropolated value mentioned earlier. If a compromise value of 13* instead of 17 is taken, the quantity of additional NPK fertiliser would be 2 million tonnes, raising the total requirement to 4.84 million tonnes, which is close to the value (4.89) arrive at in paragraph above.

48.3.10 The most significant point for consideration that emerges out of these estimates of fertiliser requirement is that wherever assumptions appear they should be related, more realistically, to the actual performance in the field, rather than an ambitious target which eludes achievement. The setting up of higher targets may have some virtues, but targets which are too ambitious would make actual achievements appear poorer, and bring discredit to the performing agencies concerned.

48.3.11 In the matter of assessment of fertiliser requirement for future years, three methods have been applied (Paragraph 48.3.1). In developing the approaches certain assumptions have been made and each of the methods has certain merits and limitations. Of the three methods, the one based on replenishment of nutrients removed by crops would appear to be straightforward. The data of nutrient removal by foodgrain and non-foodgrain crops when compared with the nutrient consumption during past few years indicate certain relationship. Thus, consumptions of N, P_2O_5 and K_2O are about 60, 50 and 10 per cent respectively of the total quantities of each removed by the harvested plant products. Surprisingly enough, the other two methods have also given rise to almost similar values. If, therefore, the targets of production of crops for any particular year are fixed, the fertiliser demand in terms of different nutrients can be easily worked out. On the above basis, the total nutrient requirements ($N+P_2O_5+K_2O$) during 1980-81 and 1985 have been worked out to be 5.6 and 6.0 million tonnes respectively. In respect of individual nutrients the computed figures in million tonnes come to : N 3.4 and 3.6; P_2O_5 1.27 and 1.3; K_2O 0.99 and 1.1 during 1980-81 and 1985 respectively.

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*Experimental data reported in Table 48.13 in Section 7 support the assumption of a similar value. High response rates are quite common at low doses particularly in non-irrigated crops (Giri G. & De. R.—Fertiliser News, 1974, 19,20).

48.3.12 The only merit of the fertiliser assessments made above appears to be that the estimates were checked with the actual consumption trend. The percentages of the values calculated on the basis of the parameters (i), (ii), and (iii) mentioned in paragraph 48.3.1, might otherwise seem arbitrary. The consumption trend showed an upward rise following the introduction of high yielding varieties of crops. The same increasing consumption trend was made the basis for the future estimates. A further increase in consumption trend will, no doubt, mark the achievement of a breakthrough in rice varieties, or in bajra and jowar. Any future estimates will have to take cognisance of such possibilities. But in the absence of a definite knowledge of the take off point, there is no other alternative than accepting the present trend of consumption of fertilisers. No separate considerations could also be taken of such parameters of production as irrigation, improved water use, pesticides, seed quality, land shaping, soil and moisture conservation, soil testing, cropping pattern and efficient farm management. Each of these influences the dosage and effectiveness of fertilisers. The dosage of fertilisers is further dependent, very largely, on their price and availability. On a microscale, an accurate estimate of fertiliser need of a soil region under a particular cropping pattern can and should be made to attain a desired degree of accuracy. But on a national scale, the task of calculation would be stupendous, even if the necessary information is available. Whether such an exercise would be worthwhile is, therefore, doubtful. There lies the usefulness of the estimates made above on simpler considerations, which are a few percentages higher than the present consumption trend, but not too ambitious and unrealistic.

Consumption Trend in Fertilisers

48.3.13 The correlation between production of foodgrains as well as non-foodgrain crops and consumption of fertilisers is expected. In fact, an increasing trend in fertiliser consumption has been noticed as the agricultural production has increased. Where cultivation is rainfed, water availability is the most important factor but it cannot be controlled. As a result, there are years of good production without the commensurate consumption of fertilisers, and years of low production even though fertiliser consumption is high. In spite of such uncertainties, there is an unmistakable rise in fertiliser consumption over the years (cf Fig. 48.1 and Table 48.8). The rate of increase is slow during the years 1951-52 to 1964-65 covering the First, Second and nearly half of the Third Plan periods. The rate

henceforward becomes faster coinciding obviously with the introduction of the high yielding varieties, and at the same time prices of agricultural produce became more favourable. To steady trend is indicative of an awareness on the part of the producers in respect of fertiliser use. An accelerated trend will be expected when a breakthrough, similar to wheat, occurs in other crops, e.g., in rice or millets, or else, when a very large coverage under the existing high yielding varieties is achieved as a result of increased irrigation facilities.

48.3.14 We sponsored a study at the Indian Institute of Management, Ahmedabad on the districtwise growth of fertiliser use in India. This study has made a few important observations in respect of the past growth patterns of fertiliser use during 1960-61 to 1968-69 in the different districts and the possible reasons behind the slowing down of the growth of fertiliser use during 1969-70 and 1970-71. Out of 338 districts data were available for 286. The factors influencing the use of fertilisers, viz., nature of crops grown and areas under various crops, percentage of gross irrigated area, rainfall and nature of soils were taken into consideration. In addition, the different intensive agricultural and high yielding varieties programmes were also considered. This study has shown that the bulk of the past growth in fertiliser use has been concentrated in a small percentage of districts. Thus, for 1968-69 less than 15 per cent of the districts account for 80 per cent of the total fertiliser use in the country, while more than 50 per cent account for only 10 per cent of the fertilisers consumed during the year. The analysis for the period reviewed has shown that less than one-third of the districts account for 70-80 per cent of the fertilisers used during 1960-61 to 1968-69. The districts which have shown a rapid increase of fertiliser use are mostly located in the Punjab, Haryana, Uttar Pradesh, Maharashtra, Andhra Pradesh, Kerala and Tamil Nadu. Over 80 per cent of the districts showing poor growth of fertiliser use are located in Madhya Pradesh, Rajasthan, Assam, Bihar, Orissa and West Bengal, irrespective of the level of fertiliser use during 1960-61. In general, the districts located mainly in the central and eastern regions show low growth rate in fertiliser use. This study could not bring out any definite relationship between the growth of fertiliser use and the various agricultural development programmes including IADP, IAAP, HYV, MCP (multiple cropping programme), etc. It has been found that there are some districts outside the above programme which have shown better performance and better growth rate in the use of fertilisers. Analysis shows further that the growth rate of fertiliser use varies among the districts mainly because of difference in the levels of irrigation, cropping pattern and diffusion of high yielding varieties in the different States.

Most of the districts with high growth rate of fertiliser use are those with high levels of irrigation and *vice versa*. There are some districts which have shown good growth rate in fertiliser use primarily due to the cultivation of commercial crops such as cotton, groundnut and tobacco in the cropping patterns of such districts. The impact of high yielding varieties on growth of fertiliser use has been mainly confined to districts with moderate to high levels of irrigation and where wheat is the main cereal crop, except in some of the southern districts where rice is the main cereal crop. The rate of fertiliser consumption may also be maintained higher as a result of favourable prices of agricultural produce.

48.3.15 The slowing down in the growth rate of fertiliser use during 1969-70 to 1970-71 has been ascribed to (a) the slowing down of further diffusion of HYVs and no significant increase in their rates of application in districts with high levels of irrigation; (b) low diffusion of HYVs in most districts with high levels of irrigation and rice as the dominant crop; (c) low diffusion of HYVs in districts with low levels of irrigation; (d) limited scope for further diffusion of fertiliser use on irrigated areas; (e) absence of rapid diffusion of fertiliser use on rainfed areas; (f) lack of timely availability of fertilisers; (g) non-availability of credit; and (h) lower prices of produce. From the above it may be concluded that the past growth in the use of fertilisers has been mainly due to (a) diffusion of fertiliser use to almost all crops grown under irrigated conditions; (b) a few commercial crops grown under irrigated and rainfed conditions; and (c) replacement of local varieties by high yielding varieties, particularly of wheat, under irrigated conditions.

48.3.16 We deliberated on the various aspects of agricultural extension work in considerable details with particular reference to the promotion of fertiliser use. In our Interim Report on Fertiliser Distribution it was brought out that there were certain deficiencies in the action programme for promoting fertiliser use which had resulted, among other factors, in the slowing down of the rate of growth of fertiliser use. In this connection we would like to refer to the discussion made in Section IV of the said Interim Report which reads as follows :

> "The Fertiliser Corporation is having a basic programme of fertiliser trials on various soils for various crops to enable its factories to give the latest advice on the proper package for certain soil conditions for certain crops grown in the areas of marketing. All the fertiliser producers are taking the help of the State Directorates of Agriculture and the agricultural universities to help them in the formulation of fertiliser routines for various soil conditions for various crops. In areas where they are introduc-

ing their fertilisers but which are not important marketing areas for the product, some amount of demonstration is being carried out. This can be taken as the basic pattern that is developing and will be developed in the next few years in the field of fertiliser promotion. Keeping in view the fertiliser promotion work which the fertiliser producers will be doing, the Commission is of the view that the Ministry of Agriculture, with the cooperation of the State Governments, should fill up only the gaps in the fertiliser promotion programme in the country. The gaps that we envisage are as follows :

(a) Areas in the country which are not the main marketing centres of any of the producers of fertilisers;

(b) Areas in the country where more than one fertiliser manufacturer has a marketing operation but it is not massive enough for an effective promotion programme.

In consultation with the various fertiliser producers, these areas should be identified and the fertiliser promotion to be done by the Ministry of Agriculture concentrated in these areas.

The Commission notes that the Ministry of Agriculture has already decided to take up a departmental fertiliser promotion programme. The main features of the proposal which is being drawn up in consultation with the Planning Commission, I.C.A.R. and State Governments for immediate implementation are:—

(i) Demonstrations secondary to National Demonstrations, oriented towards balanced fertilisers to be organised in the selected districts.

(ii) Soil testing laboratories to be made effective and supported where necessary in these districts to give a correct picture of fertiliser requirements.

(iii) Massive publicity through audio-visual media such as radio, films, etc. to support the programme.

(iv) Training of farmers to be organised intensively in cooperation with the farmers' training programme.

(v) Training of V.L.Ws, extension officers etc., to be organised on a regular basis every year.

(vi) Training of dealers and cooperative salesmen.

(vii) Assistance in the provision of distribution and production credit-bulk from commercial banks and cooperatives; credit to be given in kind."

48.3.17 From Appendix 48.7 it will be seen that there was slowing down in the rate of growth of consumption of fertiliser from 1971-72 onwards, tending to be static, which may be ascribed to the inadequate availability of fertilisers. The present hike in the price

of petroleum products has resulted in very high cost of fertilisers and also uncertain conditions of availability in the world market. In the above context, supplementation of demand over the indigenous availability by imports will be precarious. The world shortage of fertilisers has to be accepted as a reality for years to come and has to be faced. In view of the above uncertain situation and constraint imposed, the promotional infrastructure of the various agencies involved has got to reorient its activity in demonstrating more economic and efficient use of fertilisers.

Extensive vs. Intensive Use

48.3.18 A question has arisen as to what will be the best method for distribution of fertilisers under the constraint of availability. There are two ways in which the present situation can be faced, namely, (a) the intensive use of fertilisers in areas of high productivity and where the various other inputs like water, power, etc. are readily available; (b) extensive use of fertilisers at a lower dose to cover larger farming areas. If we take into consideration the first aspect, this might result in creating wider gap and disparity in the economic conditions of the farming community which is already evident because of the new farm technology. Intensive use of fertilisers for maximising production per hectare of cropped land will benefit the big farmers who are already financially well off. In developed countries intensive use is preferred in order to facilitate a well-organised marketing system. This facilities procurement of surplus foodgrains by the State marketing organisations in localised areas, thereby incurring lower cost in handling. In order to realise maximum production per hectare, fertiliser addition has to correspond to that portion of the response curve where it tends to flatten out, even though at this stage the response is lower per unit of fertiliser than that at the low-dose linear portion of the curve.

48.3.19 On the other hand, it has been definitely established that it is economical per unit of fertiliser to use the optimum rather than the maximising dose. This is because of the application of law of diminishing returns which holds good equally for high yielding varieties. A comparative analysis of the fertiliser experiments carried out using departmental recommendations aimed at maximising production and those using optimum doses shows that the latter allows a more rational allocation of fertilisers amongst crops and regions, thereby enabling not only to cover a larger area but also to increase

production.[1] The former, however, leads to a high production but necessarily of a particular crop, acting as a hindrance, so to say, to diversification of agriculture and dispersal of benefits. It thus becomes evident that if the extensive use of fertiliser is resorted to there is possibility of overall increase in production of other agricultural commodities, including foodgrains. This would help in narrowing the gap and disparity in the economic conditions of rural farming community and ensure social justice.

Consumption Target

48.3.20 The consumption targets, as will be seen from the graphs 48.4 and 48.5 follow an entirely different trend from the actuals so much so that the two trends show increasing divergence. The usual optimistic attitude in fixing the targets is undoubtedly the cause of this wide gap. The filling up of the gap is intended to be achieved by stepping up indigenous production, and where not possible, by import. The widening gap is evidently due to low indigenous production capacity as well as limited import facilities.

4 FACTORS AFFECTING EFFICIENT USE OF FERTILISERS

48.4.1 The physical, chemical and biological reactions between the soil and added fertilisers determine the availability of nutrients and hence the efficiency of fertiliser use. The type of the soil and its chemical, biological and physical properties are, therefore, important considerations in the choice of fertilisers and their time and method of applications. Crops, according to their nature and conditions of cultivation, create characteristic biological environments, which, by interacting with fertilisers, make nutrients availabile to them. A third factor of importance is the climate comprising rainfall, especially its distribution, temperature, humidity, sunlight intensity and day length. It is the interaction amongst all these factors which would determine the most efficient cropping patterns of any particular region.

48.4.2 The efficiency in the use of a chemical fertiliser depends on the form in which the nutrient element exists in the fertiliser and on its concentration in the soil solution. It is also determined by the

[1]. Chaudhri A.K. & Sirohi A.S. (1973) Indian J. Agri.Econ.28(3). 46-61 Kahlon. A.S., & Sirohi, A. S. Fert. News., 1974. 19,37.

FIG. 48.4 (PARAGRAPH 48.3.20)

PRODUCTION, CONSUMPTION, TARGETS AND UNFULFILLED TARGETS OF NITROGEN

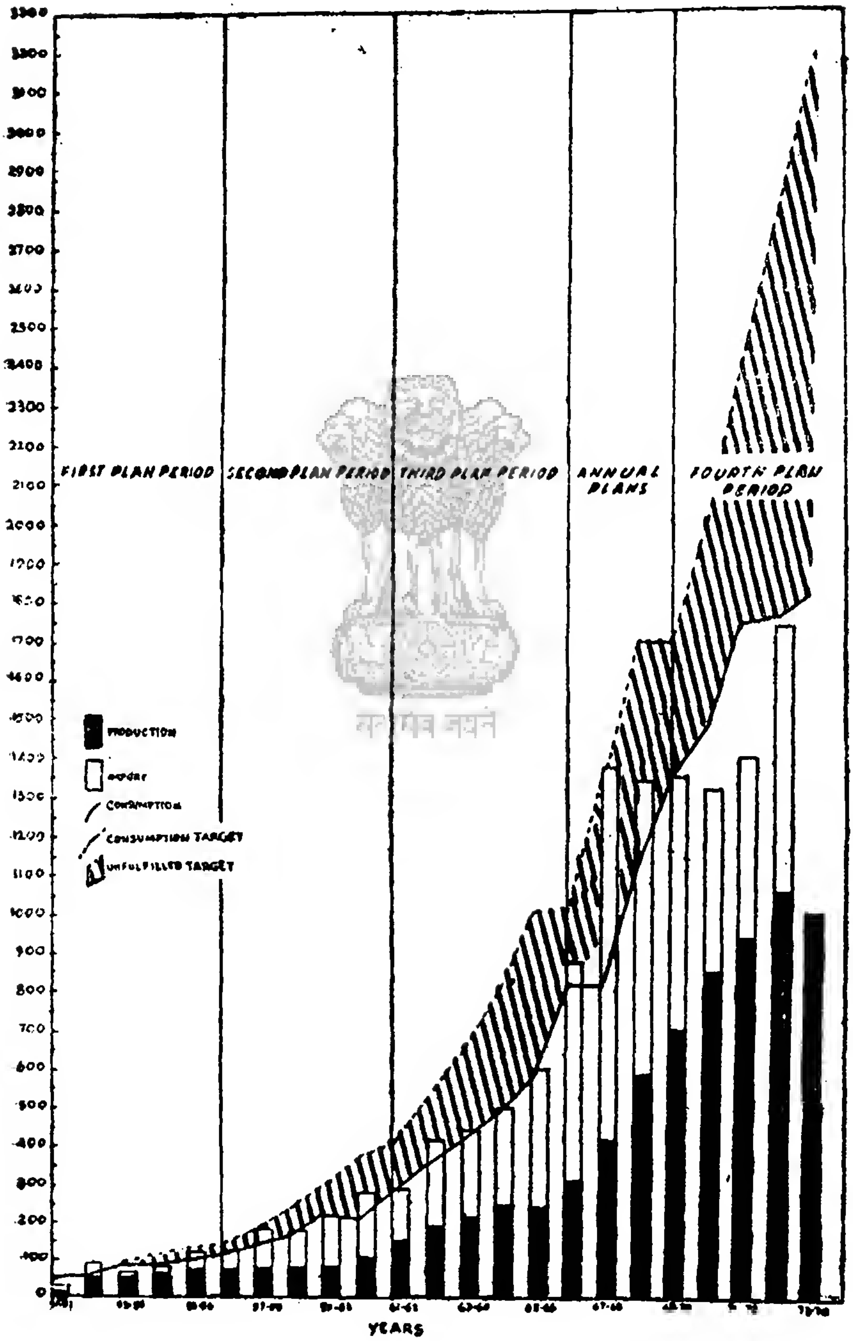
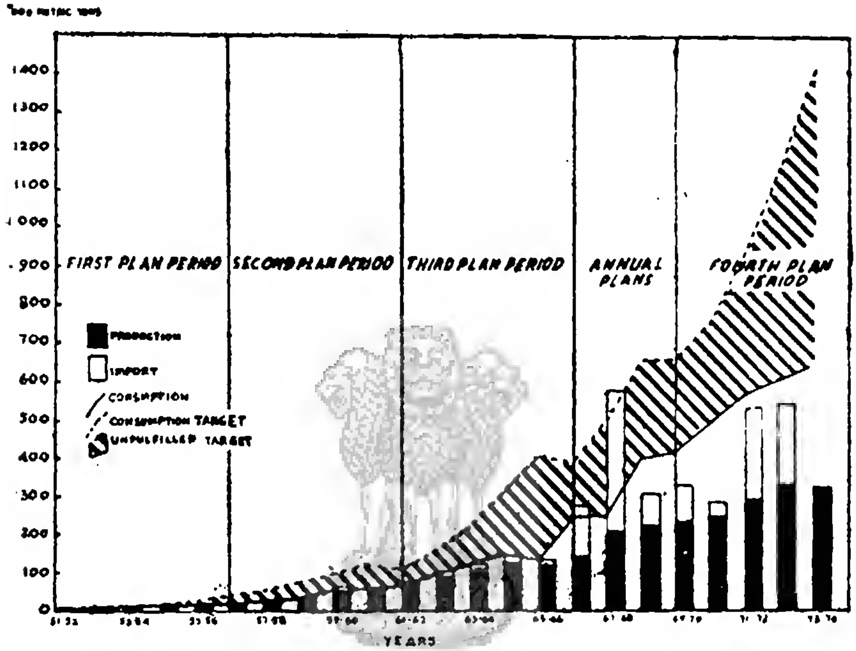


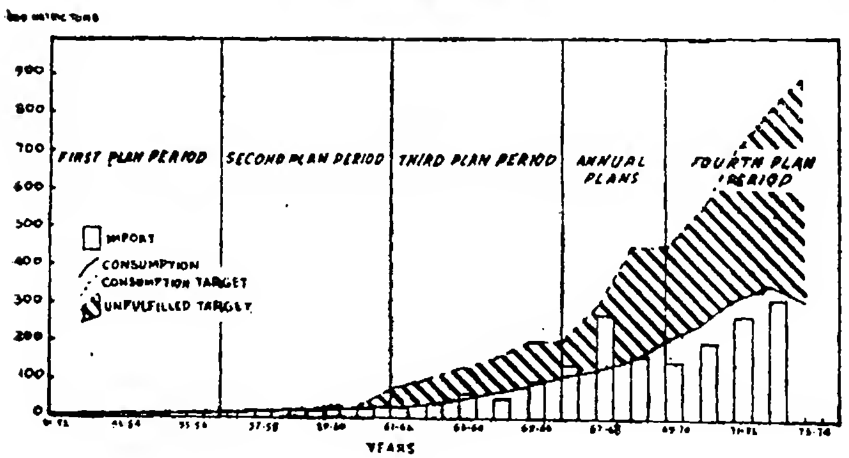
FIG. 48.5 (PARAGRAPH 48.3.20)

PRODUCTION CONSUMPTION TARGETS AND UNFULFILLED TARGETS OF P_2O_5 AND K_2O

PHOSPHORIC ACID



POTASH



relative rates at which the fertiliser is transformed in the soil into assimilable and unavailable forms. The nutrient elements of a fertiliser are required to exist in the soil in readily available forms, but their degree of availability is determined by the prevailing soil conditions and the form in which the fertiliser is applied. By the time the plants are able to absorb the nutrients, the fertiliser is likely to enter into a complex series of reactions with the soil constituents, giving rise, in general, to a different proportion of the available nutrients from that present initially. The characteristics of the soil and its environment, and that of the nutrient elements, therefore, determine the overall efficiency of a fertiliser.

Nitrogenous Fertilisers

48.4.3 Owing to soil microbial activities, all nitrogenous fertilisers applied in any form other than nitrate are ultimately converted into nitrate except under waterlogged conditions, in which the ammonium form predominates. The nitrate is directly available to plants, and if not absorbed as fast as it is formed, is lost by leaching. Plants such as paddy are capable of taking up ammonium ions under waterlogged soil conditions. Moreover, clay minerals, particularly illite and vermiculite can bind ammonium ions and prevent there loss by leaching. The possibility and extent of loss of nitrogen, therefore, depend very much upon the drainge conditions and type of the soil. For efficient use of nitrate, the period of maximum utilisation by plants has to be taken into consideration. Under waterlogged conditions of rice culture the ammoniacal form of nitrogen is usually more suited, as nitrate under reduced condition is converted into the toxic nitrite. The amide and other organic forms of nitrogen require conversion into either ammonium or nitrate ions for absorption by plants. The rates of conversion depend on soil and climatic conditions. With adequate moisture, aeration, favourable temperature and pH, the conversion into nitrate will be rapid, but under cold, west and extremely acidic condition the conversion is slow. The microbial conversion of nitrogen present in bulky organic manures into nitrate is usually slow. It can be appreciably speeded up by adding a small amount of inorganic nitrogenous fertiliser as a starter. Their efficiency, however, lies in preventing loss of nitrogen by leaching. In general, the total effect per unit of nitrogen is greater if bulky organics are suitably mixed with inorganic fertilisers. There cannot be any universally accepted nitrogenous fertiliser, because of the peculiar properties of nitrogen and its assimilation characteristics. Ammonium sulphate, which till recently, was the most common nitrogenous

fertiliser in the country is gradually being replaced by urea. Urea has steadily gained favour as a direct application material. It is used to some extent as a foliar spray on horticultural and other crops or applied in mixture with certain insecticides and fungicides. Combining herbicides with nitrogenous fertilisers is a recently developed practice which appears to be promising.

Anhydrous Ammonia

48.4.4 In view of the high cost of fertilisers, attempts are being made throughout the world to reduce their costs of production and application, and at the same time to increase their efficiency. In this context the use of anhydrous ammonia (82 per cent) has been recommended, based on experiences gained in countries like Denmark, France, USA and USSR. Denmark and USA lead the other countries in the use of anhydrous ammonia directly as a fertiliser. Of the total nitrogen used by Denmark nearly 50 per cent is constituted of anhydrous ammonia. Denmark which imports all her nitrogenous fertilisers finds anhydrous ammonia agronomically as good as, if not superior to, solid nitrogenous fertilisers. The sandy to sandy loam soils of Denmark, having acidic pH, 2 per cent or more of organic matter, an average low temperature (7.5°C), and a monthly average rainfall of 53 mm are all very congenial to the use of anhydrous ammonia. Ammonia, as soon as it is injected, considerably reduces nematode population and nitrate producing bacteria and is fixed by the clay in the NH^{+}_{4} ion form. Since nitrogen is effectively absorbed in the NH^{+}_{4} form, the temporary lack of nitrate formation does not adversely affect nitrogen utilisation. In waterlogged and moist soils ammonia remains in solution and is prevented from leaching.

48.4.5 Experiments carried out by the Department of Agriculture, Mysore (now Karnataka) and the Mahatma Phule Krishi Viswavidyalaya, Maharashtra, applying anhydrous ammonia, to paddy and sugarcane crops show that it is as good as, if not better than, ammonium sulphate or urea. Ammonia used with irrigation water has also been found to be comparable with ammonium sulphate in the case of paddy, but is slightly inferior for wheat. Additionally, ammonia reduces harmful nematode population, especially in ratoon cultivation of sugarcane. If adequate safety measures are taken, there is no reason why anhydrous ammonia should not, under suitable circumstances, replace the traditional solid nitrogenous fertilisers. The loss of applied ammonia in gaseous form varies from 0.5 to 3 per cent. Probable damage to seeds is obviated by injecting ammonia deeper by at least 10 cm than the seed location.

9—3 Deptt. of Agri./76

48.4.6 As on January 1, 1975 the market prices of urea (45 per cent N), ammonium sulphate (20 per cent N), ammonium sulphate-nitrate (26 per cent N), calcium-ammonium nitrate (25 per cent N) per tonne were respectively Rs. 2,000, 925, 1,145 and 1,095. Calculated on the basis of nitrogen content the prices per kg were respectively Rs. 4.34, 4.49, 4.40 and 4.38. Since anhydrous ammonia is not yet a marketable fertiliser in India, its market price is not known, but its production costs, which vary from one factory to another, were Rs. 1,670, 608, 1,096 and 535 per tonne as on October-December 1974, at Sindri, Nangal, Gorakhpur and Namrup respectively. The variation is so great that it is difficult to put down the average cost. If however, the average cost of production is assumed to be Rs. 1,000 per tonne, it comes to about Rs. 1.20 per kg of nitrogen, which is about one fourth of the cost of nitrogen in the nitrogenous fertilisers mentioned above. There would, however, be an ample margin in favour of anhydrous ammonia even if costs of marketing and application are taken into account. In fact, a saving of even 25 per cent in cost would act as a great incentive in favour of anhydrous ammonia when it is marketed as a fertiliser, and cost of application is included, even though anhydrous ammonia application in the field is a specialised technique. The cost of indigenous production of ammonia, unlike the other nitrogenous fertilisers, is at par with that of the imported product and is thus not unfavourable for introducing anhydrous ammonia. There is, however, an added advantage. Indigenous production would ensure supply and returns in other forms and as such has got an edge over import, if the overall economy is taken into account.

Aqua Ammonia

48.4.7 Compared with anhydrous ammonia aqua ammonia is easier to handle and apply, and is used in some countries. The low analysis (e.g., 20 per cent nitrogen) makes its transport cost high and is likely to stand in the way of its extensive use. Some other liquid fertiliser materials, such as, nitrogen solution, liquid mixed fertilisers and ammonium polyphosphate have high contents of nutrients and have greater chances of being used with irrigation water.

48.4.8 Before venturing large scale application of anhydrous ammonia, which involves new technologies and techniques both in the field and in handling from the factory to the distribution end, a series of cautious experiments have to be undertaken. Questions about the suitability of the soil texture, temperature, moisture status, basicity/acidity, calcium carbonate content etc. towards anhydrous ammonia applicaion have to be properly answered. The projects con-

templated by the Fertiliser Corporation of India in this regard in some predominantly paddy, wheat and sugarcane tracts, when completed, are likely to provide most of these answers, in addition to those pertaining to the agronomic aspects of anhydrous ammonia application. Because of the risks involved in the handling of anhydrous ammonia, it is almost certain that its use can be promoted only through well organised custom services.

Slow Release Nitrogenous Fertilisers

48.4.9 Agronomists and the fertiliser industry have long been interested in developing a nitrogen fertiliser that would generally release its nitrogen through the growing season or preferably over a long period. Such a fertiliser should result in increased efficiency of uptake by plants, minimise gaseous and leaching losses and reduce application costs. So far, three nitrogenous materials, the ureaform, crotonylidine diurea (floranid) and fused magnesium ammonium phosphate have been produced commercially to serve the purpose mentioned above. Considerable research is under way to coat fertiliser granules in a suitable manure so as to endow them with slow release property. Most coating materials increase the cost of fertilisers and present manufacturing problems. Sulphur coating is relatively inexpensive and sulphur itself is a plant nutrient. A simple, but perhaps requiring more labour is, the "mudball" technique in which a mudball of the size of a cricket ball, encasing a requisite amount of fertiliser, is implanted into the field.

48.4.10 Another approach to slow release nitrogen has been the development of nitrification inhibitors. 2-chlore-6- (trichloromethyl) pyridine under the trade name 'N-Serve' is available for this purpose. It is reported to act selectively against the soil organisms that convert ammonium to nitrate but almost nontoxic to organisms or enzymes that convert urea to ammonium ion. In concentrations of 0.1 to 0.2 per cent by weight of nitrogen contained in ammonium salts and urea, the product has shown effectiveness in sandy soils under severe leaching conditions, in clay loams subject to denitrification and under cold soil conditions when applied prior to planting. A similar but somewhat less effective inhibitor has been found in the *karanja* oil cake.

Phosphatic Fertilisers

48.4.11 Phosphatic fertilisers may be divided into four categories according to their relative water and citrate solubilities, namely, (a)

single, double and triple super-phosphates, and ammonium phosphate, in which all the phosphate is in water soluble form; (b) nitrophosphates having partly water soluble (4-6 per cent P_2O_5) and partly citrate soluble (14-16 per cent) phosphates; (c) basic slag (6-12 per cent P_2O_5) and dicalcium phosphate (35 per cent P_2O_5) with very little water soluble but almost wholly ammonium citrate soluble phosphate; (d) bonemeal and rock phosphates with no water soluble phosphate but the major proportion of the phosphate being soluble in 2 per cent citric acid solution.

48.4.12 Rock phosphates are the basic materials for the manufacture of practically all the water soluble and citrate soluble phosphatic fertilisers. They are also used for direct application provided the material is pulverised to an optimum fineness and applied in moderately to strongly acidic soils, particularly for long season or perennial crops with extensive root systems. The availability of phosphorus from applied rock phosphate is enhanced by low pH and low calcium status of the soil. Some leguminous crops have the capacity to take up phosphorus from rock phosphate and as such application of rock phosphate to legumes used for green manuring not only increases the yield of the leguminous crop but also makes the absorbed phosphorus available to the succeeding cereal crop. Experiments in India have shown that the application of phosphate with organic manures is beneficial in the sense that crop response to phosphorus is high and fixation of phosphorus by soil is minimised. A better utilisation of phosphate in acid soils when mixed with farmyard manure has also been reported.

48.4.13 Basic slag, although low in phosphorus, is one of its important and easily available sources. It is applied, preferably in powdered condition, directly to acid soils, supplying both lime and phosphorus. The alkaline nature of basic slag makes it unsuitable for use in mixed fertilisers. The bulk of phosphorus is citrate soluable, the effectiveness being enhanced by grinding the product fine. Citrate soluble phosphate in acid soils responds well, if not better, than water soluble phosphate. The efficiency of water soluble phosphate is impaired, expect under neutral to slightly alkaline conditions, due to conversion into slightly soluble iron and aluminium phosphates. Quick growing and short season crops and crops grown in neutral to slightly alkaline soils respond better to water soluble phosphates, especially at the early stage of growth. The nitrophosphates having partly water soluble and partly citrate soluble phosphates perform very well under acidic soil conditions. For long duration crops like sugarcane and cotton in black and alluvial soils, having neutral to slightly alkaline pH, the efficiency of nitrophosphates is as good as the superphosphate. Nitrophosphates are likely to provide a wide

range of compositions and relative proportions of water and citrate soluble phosphates. As such they are suitable for application under varied agroclimatic conditions. Water soluble phosphates contain phosphorus in the assimilable form and as such are preferable to the others. Unless, however, the soil conditions are taken into consideration before applying, there lies the risk of water soluble form being converted into fixed forms. For example, the availability of water soluble phosphates is reduced when applied to acid soils.

48.4.14 In this context it is worthwhile to mention that soluble phosphates are known to be converted quickly to insoluble forms when applied to the soil. In that case the effectiveness of the soluble form may be questioned, and so also the form in which the phosphate is initially added. It may be argued that the soluble phosphates are possibly converted into colloidal forms of insoluble phosphates which are equally as effective as the soluble ones. This argument is so far without valid experimental proof and should be pursued to its logical end.

48.4.15 Ammonium phosphates have several marked advantages as fertiliser materials. They are entirely water soluble, are high analysis, can be applied directly or mixed with most other fertilisers and have good physical properties. The granular products are particularly of value for use in bulk blends and for any high analysis grade of mixed fertilisers. There are other high analysis phosphates like polyphosphates which promise certain advantages and, therefore, require urgent attention as to their performance under different soil and climatic conditions.

Potassic Fertilisers

48.4.16 The potassic fertilisers are all water soluble and are available as chloride (muriate) as well as sulphate of potassium and mixed sulphate of potassium and magnesium. The sulphate of potassium is recommended for crops which are chloride sensitive (e.g. tobacco and potato). Otherwise, the choice of one in preference to the other of the potassium salts is mostly determined by their costs.

48.4.17 The problem of potassium fixation in soils is not as acute as it is with phosphorus. It is the usual practice to apply potassium prior to or at planting by broadcast method. The timing of potassium application is important where large additions are required for economic crop yields. Large amounts are often needed in highly weathered and light textured soils, and in regions of high rainfall. Usually in such cases split doses are preferred to avoid leaching.

Micronutrients

48.4.18 Micronutrient deficiency is ordinarily detected by means of visual symptoms in crops and once diagnosed, remedial measures, either by soil application or foliar spray, are more or less routine. The awareness of micronutrient deficiency has recently been intensified as a result of the spectacular yield increase of high yielding varieties of wheat and paddy by the application of zinc. The doses of zinc applied are much above the usual doses of micronutrients and this has given rise to routine checkup of zinc deficiency. Zinc is so much essential for the high yielding varieties of crops that it is now included in the fertiliser schedule.

48.4.19 The very small quantities of micronutrients which are normally required in the entire metabolic process of plants are ordinarily available in the soil, having been ultimately derived from rocks and minerals, or from impurities associated with manures and fertilisers. But with the progress of intensive cultivation and introduction of high yielding varieties the demand for micronutrients has exceeded the supply from these sources. It is now becoming customary to suitably incorporate micronutrients with the fertilisers. But since the amounts are usually very small, it is necessary to fortify them in the form of complex ions, either by reacting with chelating agents like EDTA (ethylened amine tetraacetic acid) or as metal ammonium phosphates. In this way, Fe, Zn and Mn- EDTA complexes and Fe, Zn, Mo, Cu and Co ammonium phosphates have been found to serve as good carriers of the associated micronutrients. Humus is also found to act as a chelating agent for micronutrients, and hence soils rich in humus or to which organic matter has been added stand a good chance of retaining micronutrients. Because of the high requirement of high yielding varieties, zinc is better applied as sulphate but other forms such as oxide should be equally good. The current trend is towards the marketing of balanced fertilisers fortified with micronutrients. With further growth of intensive cultivation constant watch should be kept on micronutrient deficiencies and finding suitable methods of incorporating them.

Application of Fertilisers

48.4.20 Nutrients supplied at the time of demand by plants are most efficiently used. There are fairly well demarcated periods in the course of the entire growth of a plant when nutrient demands are high. The task is, therefore, to make the nutrients available to the plants during those periods. The system involved in the process is, thus, the soil-nutrient-plant, which is a rather complex one and

hence the task of nutrition, apparently simple, raises a number of questions. For instance, what are: (a) the most efficient forms of fertiliser; (b) the optimum time of application; (c) the best methods of applicantion; and (d) the zone of placement best suited for plant uptake? In connection with the methods of application of fertilisers and their efficient use one of the basic factors to be considered is the root system of crop, its pattern of development in relation to the nature of the crop and soil properties. Sufficient information on these aspects is wanting, and no worthwhile investigation in this connection has been launched in this country. To tackle this problem requires, among other facilities, an extensive use of radiotracer techniques.

48.4.21 Another operation which deserves particular mention is the application of fertilisers as foliar spray. Foliar application of fertilisers is resorted to under specific circumstances. One of these is the inadequacy of water in the soil, e.g., under dryfarming conditions. Deficiencies which show up at late stages of plant growth demand quick absorption of the required element, for which foliar spray is the only answer. In saline and alkaline soils foliar spray is preferable because it would fertilise the crop without further increasing osmotic pressure in the soil solution. A large number of experiments on foliar application of urea have been carried out in the country but the results are not conclusive. There are situations where foliar application of urea has given good results but the bulk of experimental evidence shows that half soil and half foliar application or the whole dose applied to the soil is more efficient and economical than the entire application by foliar spray. Considerable controversy still exists about the efficacy of foliar fertilisation with urea and its economics. As leaf characteristics have a definite role to play in the absorption of nutrients, the physiological behaviour of the plant leaves needs to be studied in considerable depth before coming to a definite conclusion regarding the efficiency of foliar fertilisation with urea or any other fertiliser. The spraying of urea together with insecticides has a beneficial effect in avoiding aphid attack, apart from supplying nutrient. Similar fertiliser-pesticide mixtures may find increasing use in the future.

5 SOIL ORGANIC MATTER AND ORGANIC MANURES

48.5.1 The organic matter in the soil may vary from raw carbonaceous matter to humified substances, depending on the stages of

decomposition. The effect of organic matter and organic manures on soil productivity may be indirect as well as direct, and is, to a large extent, determined by their physical, chemical and biological nature. The direct effects relate to retention and release of plant nutrients (both macro and micro), absorption of organic components of humus, which influence favourably plant metabolism, and release of carbon dioxide following oxidation. The microbial fixation of nitrogen, and solubilisation of phosphorus compounds in the soil, the slowing down of nitrogen release from added fertilisers, improving physical and biological conditions of the soil, and moisture and ion (both cation and anion) retention capacities are among the most important indirect effects. In spite of the rapid and massive use of chemical fertilisers, the beneficial effects of organic manures have at no time been underestimated. The inadequacy of nutrients in and their slow release from organic manures and their bulk have stood in the way of fully understanding their value and importance in soil productivity. It is generally agreed that the performance of chemical fertilisers in the soil is not fully realised in the absence of an adequate amount of organic matter.

48.5.2 The organic matter content of most Indian soils is very low, because of its rapid decomposition. As a result of this, the maintenance of organic matter content at an optimum level is not possible, unless conditions favourable for its continuous formation and buildup are assured. Because of the difficulty of building an appreciable organic matter content of the soil and of maintaining favourable soil physical conditions attributed to organic matter even by adding large doses of organic manures full use of available manurial resources is not being made. This is a hazardous trend, in the sense that nonapplication of organic manure in the face of continuous application of chemical fertilisers would fail to build up good soil physical properties and reduce efficiency of fertilisers. The factors which determine a stable binding of the humus to the soil clay, minerals and other soil constituents under tropical conditions are not fully understood. Research work done in this direction is still indequate but there are indications to show that high molecular weight and nitrogen rich humus constituents bind themselves more strongly to the clay minerals. If the bacterial decomposition could be so tailored as to produce such constituents, the problems of a stable buildup of soil organic matter may not be difficult to solve. The effect of organic matter or humus is not explained simply by the plant nutrients (both macro and micro) it contains and subsequently releases to the plant growth medium. It is not merely the content of humus, but

also the texture and the nature of clay minerals present in it and of the crop that decide the effectiveness of humus in increasing soil productivity. A high dose of nitrogenous fertilisers is detrimental to yield, but in the presence of organic matter the effect is no longer unfavourable. Of the added nutrients 50-60 per cent are taken up directly, but the remaining portion comes from the organic fraction. Sometimes, humus substances or its degradation products have the unique property of providing physiologically active substances, e.g., phenols and quinones which are known to improve the otherwise nonoptimum condition caused by lack or excess of one or more growth factors. It may perhaps be categorically stated that better yields could be obtained by using chemical fertilisers in humus-rich soils.

Sources of Organic Matter

48.5.3 Natural waste products are the most important sources of organic matter, but their values as sources of plant nutrients and soil conditioners vary considerably. Waste products include a host of materials, such as cattleshed waste, sugarcane bagasse and trash, stubble, weed, straw, night soil, town refuse, sewage, sludge, slaughter house waste, lac and wool wastes, poultry litter and bird droppings, oilcakes, fruits and vegetables processing wastes, pressmud, saw dust, rice husk and bran, tobacco waste, seed waste, forest litter, marine algae and sea weeds, water hyacinth, tank silt, jute sticks etc.

48.5.4 Organic wastes, especially those of plant origin, are mostly carbonaceous in nature. Their decomposition will give rise to a large proportion of carbon dioxide and water but much smaller proportions of humus and ammonia. Unless methods are found to increase the humus contents, the full benefits of organic manure cannot be realised. Its bulk, and consequent cost of transport are disadvantageous. Suitable methods of reducing bulk by chemical, microbiological or other treatments need to be evolved, or else, small manufacturing concerns dealing with waste utilisation may be located as close to the place of application as possible. Enrichment of organic wastes with nitrogen by oxidative ammonification and with phosphates will considerably enhance their manurial value. The commercialisation in Germany of N-lignin, a nitrogen enriched lignin sulphonate from paper industry waste, is an instance in point.

48.5.5 Attempts are being made by the Ministry of Agriculture and Irrigation to mobilise urban and rural composts, sewage and sullage, green manuring and dung slurry from gobar gas plants. Under the urban compost programme the local bodies are required to convert

the refuse and nigrt soil into compost and supply the products to farmers of the adjoining areas . The manner in which the urban waste is processed determines its manurial value, which, as already mentioned, can be enhanced by suitable treatment with ammonia and phosphatic compounds. This is not being done at present. Intimately connected with their utilisation is the efficient disposal of wastes so essential of keeping urban areas clean. There is ample room for improvement in this field, and unless mechanical processing is adopted, the problem of disposal will not be solved. On calculating the overall economics and longterm benefits accruing from it, mechanical processing may not be a costly venture. It should be a joint programme in the State sector of the Ministries of Agriculture, Health, Works and Housing and Self Government. The Fifth Plan envisages the setting up of 45 mechanical composting plants in cities having a population of 3 lakhs and above, and the production of 1.5 million tonnes of enriched manure containing not less than 3 per cent NPK. This kind of activity should develop further as a continuing venture.

48.5.6 In developed countries, deliberate attention is being paid to recycle urban wastes for the purpose of converting them, largely by mechanical methods, into suitable forms for soil use as sources of plant nutrients. Similar possibilities exist in India. There are 18 big cities having a population of 5 lakhs and above, generating 250 to 3,500 tonnes of wastes per day. Calcutta, Bombay and Delhi produce enough wastes to feed more than two mechanised plants each having a capacity of 800 tonnes per day. Madras, Hyderabad, Ahmedabad, Bangalore and Kanpur can have one such plant each. There are 120 cities which have population of 1 to 5 lakhs producing 50 to 250 tonnes of wastes per day. Out of these, 46 cities produce more than 100 tonnes of wastes per day. The latter may have medium sized plants and the rest may have smaller plants. There are a number of methods at present available for compost manufacture by mechanical means, and plant fabrication facilities are available in Bombay and Calcutta. In view of the shortage of chemical fertilisers, it is becoming increasingly necessary to establish such compost plants to supplement plant nutrients in the soil. The benefits of the use of organic manures either alone or in combination with chemical fertilisers have been elaborated earlier. In view of the importance and difficulty of building up the organic matter status of tropical soils, the recycling of processed wastes in all available forms is a matter of urgent necessity.

48.5.7 The potential of sewage and sullage available in cities and towns as source of plant nutrients and irrigation water is enormous. The problem is of mobilising these resources which are otherwise allowed to go waste. It has been estimated that the available 800

million gallons per day of sewage and sullage can yield an annual outturn of 60,000 tonnes of NPK, and irrigation water equivalent to the performance of 1,600 tubewells each having one cusec capacity. The Fifth Plan envisages 200 sewage/sullage centres estimated to benefit agricultural production in an area of 24,000 hectares. Utilisation centres like this should multiply and become a continuing feature of country's development plans.

48.5.8 Rural compost programme covers a very wide area and offers a gigantic potential of organic manure and plant nutrient resources. The relevant schemes have, of necessity, to be run by the local agencies who should be given suitable technical assistance and incentives. More than 40 per cent of rural compost is constituted of dung, most of which is used as fuel, because other forms of fuel are in short supply. It has been estimated that the annual production of dung corresponds to 2.9, 1.5 and 2.5 million tonnes of N, P_2O_5 and K_2O respectively. By comparison, the consumption of fertilisers $(N+P_2O_5+K_2O)$ in 1970-71 was 2.3 million tonnes and the corresponding production of foodgrains was 108 million tonnes. The loss in manurial value caused by the use of dung as fuel is, therefore, enormous, which can be arrested by introducing gobar gas plants. The fuel and manurial value are both retained in the process. The economics of the innovation may stand in the way of its wide acceptability, but technological improvements and simplification as demanded by exigencies of situation, are not ruled out. The economics is more important because the equipment has, of necessity, to be adaptable on a village scale.

48.5.9 In multiple cropping programmes, leguminous crops should find their proper place because phosphate fertilised legumes offer a very good and on-the-spot applicable source of organic matter combined with nitrogen and phosphorus. In mixed farming also (Chapter 33) there are opportunities of optimising the utilisation of organic wastes. Appendix 48.8 gives rough estimates of the availability of some of the waste products which are a potential source of plant nutrients. These are based on the estimates of production and contents of wastes originating from either crops or animals. The importance of organic manures and organic matter lies not so much in supplying plant nutrients as in permanently improving the physical and biological conditions of the soil. Moreover, the application of organic matter and wastes ensures to some extent one of the ways of the much desirable recycling of limited natural resources.

6 CHEMICAL FERTILISERS AND SOIL AMENDMENTS

Availability of Fertilisers

48.6.1 The factory of Fertiliser and Chemicals, Travancore Limited which was the first in India to start manufacture of ammonium sulphate by wood gasification went into production in 1947. The Sindri Fertiliser Factory was commissioned in 1951 for mnufacturing ammonia from nitrogen of the air and of ammonium sulphate from ammonia and gypsum. Prior to this, ammonium sulphate was being manufactured from ammonia obtained by the destructive distillation of coal. In the pre-independence era, the fertilisr use was mostly confined to Government experimental stations even though farmers became conscious of fertilisers in the wake of the Grow More Food Campaign of the 1940's. Otherwise, fertiliser application was limited to plantation crops like tea, coffee, garden crops etc. and for valuable cash crops like irrigated sugarcane, cotton, potato etc. In the First and Second Five Year Plan periods the use of fertilisers for food crops had just begun to show its impact. In the Third Plan period the use of fertilisers was steadily growing and the year 1966-67 saw a tremendous growth rate which was about 60 per cent over the previous year. This was an eventful year because of the introduction of the fertiliser responsive high yielding varieties of food crops. From the trends in production, import and consumption of fertilisers from 1961-62 onwards, it is to be noticed that the fertiliser production was sluggish during the Third Plan period but the demand went on increasing. From 1968-69 production started picking up but even then there were substantial shortfalls in production, which were met by imports. During the first three years of the Fourth Plan there has been considerable increase in the production of nitrogenous fertilisers, but in case of phosphatic fertilisers the increase has been marginal. Practically the whole of potassic fertilisers are imported as the annual indigenous availability is limited to 1,000 to 2,000 tonnes of muriate of potash only. As the present crop production technology is mainly dependent on progressively larger use of fertilisers, the gap between the availability and demand is going to widen from year to year. It will become necessary, therefore, to resort to imports unless, of course, the fertiliser production in the country is substantially stepped up. In a vital sector like fertilisers, the shortfall in production is of disastrous consequences. All available resources should be mobilised to reduce a big shortfall, particularly in a field where the country's technological capability is of no mean order. The problem is often one of management and a good deal of improvement is possible.

Raw Materials and Feedstock

48.6.2 With the exception of natural organic manures and by-products of coke oven and steel industries and some naturally occurring water soluable substances, fertiliser raw materials usually require chemical processing in order to convert the nutrient elements into forms that can be readily utilised by plants. Chemical fertilisers thus obtained have minimised the use of indigenous or synthetic manures and have established a place of prominence in plant nutrition. With the advancement of technology in chemical fertiliser industry it has been possible to reduce the cost per unit of plant nutrient. The high content of nutrient elements in chemical fertilisers has further facilitated their transport, storage and application at lower cost, and hence general preference of the farmers for them. The major nutrients, viz., N. P_2O_5 and K_2O which are required in relatively large quantities have received the highest attention in the manufacturing industries.

Nitrogen

48.6.3 Fixation of atmospheric nitrogen is the first step to make this inexhaustible source available to plants. With the exception of leguminous plants, most plants cannot make use of the free nitrogen of the air, unless it is chemically processed into suitable compounds. It is recognised that the starting material for fertiliser nitrogen is ammonia, for the synthesis of which nitrogen of the air provides one of the components. The other component, hydrogen, is more costly and is obtained from water, or from any fuel material through a series of reactions involving interactions between fuel, oxygen and water. Hydrogen could be produced using a variety of feedstocks, e.g., (a) natural gas; (b) liquid petroleum gas; (c) methane; (d) naptha; (e) heavier fraction of petroleum, e.g., fuel oil, LSHS (Low Sulphur Heavy Stock) etc; (f) crude oil; (g) coke oven gas; (h) coal, coke, lignite; and (i) electrolysis of water by means of electric power. The existing patterns of feedstock used for hydrogen and hence ammonia production in the country are shown in Appendix 48.9. Of the important feedstocks which are economically feasible and whose technologies are well known, natural gas, naptha and fuel oil stand out prominently. But their indigenous supply being limited, dependence on import has created problems as a result of the oil price rise. In this context coal as feedstock has certain advantages. There are, however, technologist problems with coal but they are not insurmountable.

Phosphorus

48.6.4 Row materials required for the production of phosphatic fertilisers are: (a) rock phosphate; (b) sulphur; (c) nitric acid; (d) hydrochloric acid; and (e) electricity and fuel oil. Animal bone, a foreign exchange earner, is also a source of phosphate but its use after due processing as animal feed is at present more important. Till recently, the entire requirement of rock phosphate was imported from USA, Jordan, Egypt, Morocco and some other African countries. Deposits of good quality rock phosphate have recently been discovered near Udaipur in Rajasthan, which have been found suitable for the manufacure of phosphatic fertilisers under trial runs by Gujarat Fertiliser Co. Ltd., Hindustan Zinc Ltd. and in the FCI fertiliser factory at Trombay. Another deposit of phosphorites has been discovered in Singhbhum, Bihar. Trials suggest that although poorer than rock phosphate in phosphorus content, phospherite is amenable to direct application to acidic soils as a good source of phosphorus. To the extent indigenous phosphate supply is made available, foreign exchange to import phosphorus fertilisers will be saved.

48.6.5 The production of phosphoric acid by wet process is technologically simple but requires considerable amount of sulphur. There is no proven deposit of sulphur in the country. The recovery of sulphur from coal and crude petroleum is also not a feasible proposition as Indian coal and crude oil are generally low in sulphur content. The other source of sulphur is pyrites, some deposits of which have been found at Amjhore in Bihar and Saladipura in Rajasthan. Projects taken up with the help of the above sources of sulphur would hardly create any impact on the national requirement of phosphatic fertilisers. It is, thus, to be seen that if the sulphuric acid route is continued for production of phosphatic fertilisers most of the sulphur requirement has to be met by importation. The international sulphur market has fluctuated widely during recent years and there has been crisis in its supply position. In any case, the projects under production based on sulphur have to be provided with the required amount of sulphur through imports involving a heavy drain on foreign exchange. It would be prudent to avoid sulphur in future projects and follow other routes in the manufacture of phosphatic fertilisers.

48.6.6 The alternative method for the manufacture of phosphatic fertiliser uses nitric acid which can be indigenously manufactured by oxidation of ammonia. The FCI is already following the nitric acid route and manufacturing nitrophosphates containing 30 per cent or more water soluble phosphates. In the fertiliser programmes of the country there is a preference for water soluble phosphate, but the phosphatic fertiliser that would be produced by following the nitric

acid route would not be fully water soluble even though a substantial part could be brought into water soluble form through improved technology. The use of hydrochloric acid for the acidulation of rock phosphate and extracting the phosphoric acid by means of organic solvents is another alternative, but the current knowledge of the process and commercial experience are not adequate for a general programme.

48.6.7 In view of the controversy over the radio of water soluble to citrate soluble forms of phosphate it would be necessary to have an extensive programme of field experimentation for verification of the efficiency of the above two forms of phosphates and optimum ratio of the two forms in crop production under varied soil and climatic conditions. From experimental results so far obtained it has been found that citrate soluble phosphate (dicalcium phosphate) is sometimes superior to or at par with water soluble phoshates in the acidic soils of the country and for long duration crops. In case of some crops and soils the water soluble forms appear to respond favourably. Indian agronomists contend that 50 : 50 proportion of water soluble and citrate soluble forms of phosphate is suitable under nonacid soil conditions. As the international market of sulphur sometimes becomes precarious, it may not be worthwhile to depend on imported sulphur on long term basis for the production of water soluble phosphates. In any case, if the difference in crop response between water soluble and citrate soluble phosphate is not wide, it would be advisable to depend on indigenous raw materials in order to sustain production and save scarce foreign exchange.

48.6.8 The other important route of phosphatic fertiliser production is electrothermal. This process requires a very large amount of electricity amounting to about 5,500 KWH, for each tonne of P_2O_5. The power supply in the country is inadequate and the cost of power is also high. The process could be made successful if low cost power can be made available in large quantity. Of course, the capital expenditure in phosphate manufactured through the electrothermal process will be much higher than that by the wet process. The phosphatic fertiliser industry has to decide on the future course of action depending on the indigenous availability of the raw materials, cost, energy requirement and technology.

48.6.9 In the background of rapidly increasing demand for fertilisers, the hope of self-sufficiency recedes further and further. The situation in world production being unfavourable we must attempt to attain self-sufficiency in a vital sector like fertilisers. Our fertiliser production is handicapped not only by paucity of raw materials, but also by the inefficiency of men and materials. The later are remediable deficiencies. About raw materials, cost and technological problems

stand in the way, but are not insurmountable. The choice of fuel oil and coal as feedstock for ammonia production instead of naphtha has been emphasised. But in respect of both certain specific problems have to satisfactorily resolved. Fuel oil is cheaper and more easily available than naphtha, but a good proportion has to be imported. Coal is indigenous and once the technological problems are sorted out, following the successful completion of three plants by the Fertiliser Corporation of India at Ramagundam, Talcher and Korba, the choice of coal in preference to others is bound to be overwhelming. The feasibility of changing over to powder coal gasification in the oil based plants under construction at Haldia, Nangal, Phulpur, Panipat, and Bhatinda should be looked into. The question of economics has to be weighed in its totality, in which indigenous availability of coal, returns in terms of employment in related sectors of mining, and accessory industries have to be taken into consideration. The alternative suggestion to import the much cheaper ammonia to satisfy immediate needs has to be critically analysed. Provided the projects of manufacturing ammonia indigenously are allowed to proceed unhampered, import of ammonia, if at all necessary, may be resorted to as a short term measure. For a long term plan of developing nitrogenous fertiliser capacity, there is no alternative to indigenous production.

48.6.10 The problems in respect of phosphatic and potassic fertilisers appear to be far more difficult, because of the inadequacy of indigenous raw materials. For phosphatic fertilisers the two important raw materials are rock phosphate and sulphur. The discovery of considerable phosphate rock deposits at Jhamar Kotra in Rajasthan and in smaller quantities in Andhra Pradesh and Singhbhum (Bihar) is recent. They are no doubt immediately usable provided the position of sulphur is assured. The indigenous sources of sulphur are Amjhore pyrites, Saladipura deposits in Rajasthan and those available from copper, lead and zinc smelting plants. If geological explorations are intensified there is no knowing that other sources may not be dug up. In fact, several new deposits have recently been found in Rajasthan and Uttar Pradesh. While such explorations should be allowed to go on on an extensive scale, it would be wise to mop up indigenous sources and build up phosphatic fertiliser industries. Realising the spreadout of the lean resources it may be advisable to construct smaller units rather than large sophisticated plants. Use of sulphur in large quantities for phosphatic fertiliser production has been largely avoided by using nitric acid production of nitrophosphates by the Fertiliser Corporation of India. Perhaps this is the best solution of the sulphur problems.

Potassium

48.6.11 In the absence of any good source of potassium salts or minerals, all the requirements of this element are being met by imports. Woodash, plant residues, distillery wastes, blast furnace and cement kiln dust, potash contents of which vary from 5 to 25 per cent., have long been used as supplemental sources of potassium particularly for acidic soils, but their availability on a commercial scale is not assured. Recently, potassium schoenite, a double sulphate of potassium and magnesium recovered from marine salt bittern, have been tried in green house experiments[1] and in the field* with considerable success on various crops and in different types of soils. Potassium schoenite containing 24.3 per cent K_2O and 9.8 per cent MgO has given almost the same yield and dry matter as KCl and K_2SO_4 in the case of a crop sequence of wheat (HYV), fodder, maize and bajra. The medium black, alluvial, red and yellow and lateritic soils used were medium to low in available K, Mg has not shown any adverse effect and has, in fact, raised the exchangeable Mg content of those soils which are low in Mg. However, Mg in the exchangeable form is known to behave like alkali ions in some clay minerals. It is, therefore, necessary to watch the effect of continued application of potassium schoenite before it can be recommended as a potassic fertiliser. But where exchangeable Mg content is low, as in lateritic and acidic soils, schoenite would serve the double purposes of supplying both potassium and magnesium, and merits recommendation as a fertiliser. The experiments show great promise and if found successful without any side effects of Mg, bittern, which is a waste product of marine salt industry, may be a good source of potassium. According to the present capacity about 1 million tonnes of purified potassium schoenite may be recovered annually. It may also be useful to find out whether potash feldspar and mica could be made to yield their potash by chemical processing.

48.6.12 There is another point to consider in regard to phosphate and potash. These two elements are not subject to the huge loss suffered by nitrogenous fertilisers. While a small portion of potash may be lost by leaching, none of phosphates goes out of the soil which retains all the phosphate and bulk of potash either in an unavailable form or in deeper layers beyond the reach of plant roots. Consequently, some kind of recycling process may be exploited to make the locked up phosphate and potash available for subsequent

1. Ghosh. A. B., 1975. Symposium on Potassium in soils, fertilisers and crops, held under the auspices of the Indian Society of Social Science and Indian Potash Limited at OUAT, Bhubaneswar.

*Private Communication from Dr. A. B. Ghosh, IARI, New Delhi.

crops. Rotations including deep rooting crops may be thought of as one. Straw removes much larger amounts of phosphate and potash than are added as fertilisers. Returns of straw, not utilised otherwise, to the soil in the form of compost would considerably undo this depletion.

Fertiliser Analysis

48.6.13 Fertilisers are usually evaluated on the basis of the quantity of the plant nutrients contained in them and the forms in which they are present. The commercial value of fertilisers is assessed in terms of nitrogen, phosphate (P_2O_5) and potash (K_2O) contents and also the forms in which they are present. On the form of the particular nutrient in a fertiliser depends its availability as well as efficiency. Fertilisers containing only one of the above nutrients are called straight fertilisers, while others containing two or more of the nutrients are known as complex/compound and mixed fertilisers. The methods of determination of the nutrients vary from one country to the other but most countries have adopted official methods for the analysis of fertilisers and for approximate evaluation of their quality. The Fertiliser (Control) Order, 1957, includes prescribed methods of analysis of N, P & K in fertilisers, on the basis of which certain specifications as to their quality have been arrived at. It is necessary that these methods are updated and revised in the light of newer and more accurate methods of analysis available. The revision is all the more necessary in view of the introduction of new high analysis fertilisers and various formulations of complex and mixed fertilisers. With this objective in view it is recommended, in line with a similar recommendation made in our Interim Report on Fertiliser Distribution, that a Committee of analytical and agricultural chemists drawn from the IARI, agricultural universities, State departments of agriculture and fertiliser industry should go into the various details to suggest suitable methods of analysis for general acceptance throughout the country. This Committee should also review the methods at intervals as new knowledge becomes available.

48.6.14 With the gradual spread of scientific agriculture, the fertiliser consumption will continue to increase. To cope with the demand, the fertiliser industry must expand suitably and in a planned manner. With developing awareness, the preference of the farmers will be directed towards more efficient and at the same time less costly fertiliser materials. Within a span of two decades, the 'low analysis' nitrogenous fertilisers, viz., ammonium sulphate, calcium ammonium nitrate, ammonium sulphate nitrate etc. which were dominating the market have been replaced by 'high analysis' nitrogenous ferti-

lisers, viz., urea, ammonium nitrate etc. Urea was not, till recently, acceptable to farmers in the face of the superior performance of ammonium sulphate. With proven agronomic effectiveness as a nitrogen carrier, and having desirable properties of high analysis, nonexplosiveness, and lower price, urea has gained rapid popularity. In the country's production pattern also it has gained substantially, which is a healthy sign. Its higher analysis gives it a distinct advantage over ammonium sulphate in view of the cost advantage gained per unit nutrient on account of transport, storage, field application etc.

48.6.15 Single superphospate which is a low analysis fertiliser and which has dominated the world market for more than half a century is being replaced by triple superphosphate and ammonium phosphates in view of the high percentage of their nutrient contents. Even in the export market, high analysis phosphoric acid is replacing the rock phosphate on account of reduced shipping, transportation and handling costs. The trend towards high analysis granulated mixed fertilisers apparently continues. New high analysis materials, such as, urea, ammonium phosphates and polyphosphates being economically competitive, will be rapidly adopted. The fertiliser industry should aim at developing technology for meeting requirement of high analysis fertilisers, straight and complex/compounds, so that the materials of higher efficiency could be made available to the farmers at a low cost.

Classification of Fertilisers

48.6.16 Single superphosphate which is a low analysis fertiliser on soil reaction. In this way, three classes may be recognised, viz., (a) acidic or acidforming, (b) neutral, and (c) basic or alkaline. According to their degrees of acidity or basicity the fertilisers at present being manufactured in the country are listed in Appendix 48.10.

48.6.17 Ammoniacal fertilisers and those (e.g. urea) which on application to the soil are converted into ammonia have residual acidity of varying degrees at the expense of soil calcium. This results from the formation of hydrogen ions by the microbial oxidation of ammonia into nitrate. Continued use of such fertilisers eventually results in the generation of acid soil and consequent deterioration of soil physical properties and injury to growing plants, unless timely corrective measures are taken. The soils that are already fairly acid or those which are prone to be acidic, e.g., sandy soils, are the first to show decreased crop yields. On the other hand, sodium nitrate, calcium nitrate and calcium cyanamide reduce acidity in soils owing to their alkaline or basic reactions. Calcium ammonium nitrate (CAN) keeps the soil reaction near neutral. As the fertiliser

use increases, the problem of acidity in soils accentuates. In this connection, greater attention has been paid to soils of the humid areas which have no lime reserve and are prone to generate acidity. Fertilisers that leave a basic or alkaline residue generally present no serious soil problems except in rather impermeable heavy or alkaline soils which are liable to injury by the introduction of too much sodium in the exchangeable form.

Physical Condition of Fertilisers

48.6.18 The physical properties and conditions of a solid fertiliser are often a major consideration in its application to the soil. For instance, hygroscopic fertilisers, unless protected, get sticky, cake under storage pressure, and lose drillability. From a knowledge of values of critical relative humidity, which determines whether a fertiliser is going to be hygroscopic or not, it is found that most of the fertilisers under humid conditions prevailing in the eastern and southern parts of the country will be rendered useless from the point of easy application. Because of the likelihood of deterioration of physical quality, the Fertiliser Control Order has specified the moisture contents of various fertilisers, which will maintain them in good condition. Addition of limestone, where compatible, improves physical quality of certain fertilisers, making them suitable for use in dry mixes.

48.6.19 The smaller particle size of partially or slightly soluble fertilisers is known to enhance release of plant nutrients. The particle size also influences the physical condition of the fertiliser. The finer the particles, the greater is the tendency to cohere and cake under pressure on storage. Granulation prevents such caking, and is given considerable attention by fertiliser manufacturers. The bulk density or apparent specific gravity is another physical property which has a bearing on storage, transportation, bagging and use of fertilisers, a higher apparent specific gravity being favoured. The drillability or ease of flow of a fertiliser is at its best when the particles are dry, uniform in size, spherical in shape and of such a size as to minimise the cohesive forces between them.

48.6.20 The poor physical condition of a fertiliser can usually be largely or completely overcome by one or more of the following expedients: (a) regulation of the initial moisture contents; (b) proper curing to ensure completion of chemical reactions; (c) use of the right kind and quantity of conditioning agent to hinder coalescence of the individual particles; (d) granulation of the fertiliser, or, with mixtures, use of ingredients having uniform and relatively large parti-

cle size; (e) transport in moisture repellent bags; (f) protection from extremes of atmospheric temperature and humidity; and (g) storage in low stacks or piles so as to avoid high pressure.

48.6.21 The granulation of fertilisers whereby the particles are converted into spheroids of nearly uniform size and composition promotes good physical condition. A number of fertiliser materials including ammonium nitrate, ammonium phosphate, nitrophosphate, superphosphate, urea etc. are marketed wholly or partly in granular form Granulation is a common practice in the European countries, USA and Japan and is receiving adequate attention in India as well.

48.6.22 Packaging in moisture repellent containers is essential for the maintenance of good physical condition, specially in the humid tropics, of hygroscopic fertiliser materials and mixtures that have received proper processing treatment. Multiwall paper bags having one or more plies or asphalted paper are in most common use. Presently polythene lined paper bags or gunnies are being used for better protection against moisture.

Fertiliser Grades

48.6.23 With a view to increasing the efficiency of fertiliser use and promoting balanced utilisation of the nutrient elements by crops, there is a recent shift towards manufacture of complex/compound and mixed fertilisers. These materials are shown by grade designation suggesting the percentage contents of N, P_2O_5 (available) and K_2O (water soluble). The nutrient elements other than the above three are usually omitted from grade designation although mention is made of the presence of secondary micro nutrients. The suitability of the different grades has to be related to the particular crops and fertility status of the soils. The extension agency has a responsible part to play in guiding the farmers in the use of the available grades and supplementation by straight fertilisers, whenever necessary. Soil testing data and fertility index maps should help in channelising the fertiliser distribution, so that proper grades are available to the farmers in relation to their soils and crops.

Quality Control and Legislation

48.6.24 In our Interim Report on Fertiliser Distribution we deliberated at considerable length on quality aspect of fertilisers (cf Section X). The replies of the State Governments to the questionnaire issued by us and also the discussion with the State Governments helped in analysing the various aspects contributing to quality of fertilisers as are made available to farmers. The following items were

considered by us: (a) complaints from the States regarding substandard quality of fertilisers; (b) factors accounting for deterioration in quality, namely, adulteration due to difference between free market price and official price of fertilisers, and deterioration due to storage; (c) existing arrangements for the analysis of fertiliser samples; (d) quality control at manufacturers' level; (e) quality control at the distribution level; (f) standardising methods of sampling and analysis; (g) arrangements of rapid testing; (h) role of agricultural universities; (i) adequacy or otherwise of the Fertilisers (Control) Order; (j) need for a Fertiliser Act on the lines of the Insecticides Act of 1968; (k) authorities for testing and certifying quality and instituting legal action; (l) quality control organisation at the state level; (m) extension education of farmers to identify quality of fertilisers; and (n) ensuring better quality through minimising number of products marketed.

48.6.25 Based on the above studies and analysis of diverse situations at which quality deterioration might take place, we made the following interim recommendations which are reiterated below.

(i) Measures to introduce efficient methods of storage should be intensified so that one of the basic factors giving rise to complaints regarding loss of quality is removed.

(ii) Fertiliser factories that are licensed in future and such other factories which do not have quality control facilities should be required to institute quality control on fertilisers including methods of statistical quality control. The Indian Standards Institution should address itself to establish standards for fertilisers where these are not available. The manufacturers should be induced to come under the ISI quality marking system. The ISI should also bring out standards for fertiliser-pesticide mixtures in anticipation of their becoming a part of the future consumption pattern.

(iii) The manufacturers and the State departments of agriculture should take steps to enlarge their activities in the matter of drawing samples at frequent intervals, analysing them and bringing the results of analysis to the attention of the farmers. Statewise and districtwise targets for the drawal and analysis of fertiliser samples should be fixed. The period of sampling should coincide as far as possible with the storage time of fertilisers at the consumer end. The State Governments should adequately strengthen their organisational set up for quality control by equipping their laboratories for handling increasingly large number of samples. In order to ensure that substandard fertilisers are not sold to farmers, it is necessary that the results of analysis of samples are made available within 15 days from the date of drawal of samples.

(iv) The feasibility of supplying high analysis fertilisers in small sealed packs of 15 to 20 kg., corresponding to per acre requirements of nutrients should be examined. Where the supply in small sealed packs is economically not feasible, the system under which farmers could jointly buy fertilisers in large packs and distribute among themselves according to individual needs may be tried by cooperatives.

(v) The mehods of drawal and analysis of fertiliser samples should be uniform all over the country and brought within the scope of the Fertiliser (Control) Order and the quality marking system of the Indian Standards Institution. A central Committee of analytical chemists representing the agricultural universities, the ICAR, the State agricultural departments, the fertiliser industry, the Indian Standards Institution, the National Test House and other quality control laboratories at the national level should be constituted to undertake the task of formulating standard methods of analysis and exercising periodical reviews. A Central laboratory should also be set up to keep continuous vigilance in the matter of updating quality control measures and disseminating information to the State laboratories. The Central laboratory should also have arrangements for training the quality control personnel engaged in the drawal and analysis of fertiliser samples in all the States.

(vi) The existing State laboratories need to be strengthened both in terms of equipment and staff so as to ensure that the results of analysis flow back to the field more rapidly. Faster analytical procedures should be organised to carry out preliminary analysis and samples found substandard may therefore be subjected to analysis by the conventional methods.

(vii) It should be possible for agricultural universities to develop methods of analysis which are comparatively simple and quick. The universities should also help in imparting training to the quality control personnel in the methods of drawing and analysing the samples. For this purpose the new quality control laboratories should preferably be on the campus of the universities so that the latter could assist the laboratories in an advisory capacity.

(viii) The legal procedure under the Fertiliser (Control) Order for trying offenders should be simplified. Summary trials of offenders should be introduced. The Fertiliser (Control) Order should be amended to provide for penalties on the lines of

the procedure in the USA where, as noted by the Committee on Fertilisers, penalties of three times the value of the deficiency were imposed if the product was not up to the declared standard.

(ix) An officer of the rank of Joint Director of Agriculture should be put in charge of a separate Input Cell which should be set up in each State and be made responsible for taking such steps as are necessary for the maintenance of quality of all inputs including chemicals and fertilisers.

(x) By making use of publicity media, farmers should be educated with regard to the facilities available for the testing of fertilisers and distinguishing the standard material from the spurious ones. The Fertiliser (Control) Order should be translated into local languages and made available to the public.

(xi) The number of fertiliser products should be minimised to have better scope for enforcing quality control on them.

Mixed fertilisers

48.6.26 The mixed ferliliser is a processed material made out of individual fertiliser materials in suitable blends to permit application in the field in one operation. In spite of this obvious advantage, the use of mixed fertilisers apparently prevents application of single nutrients corresponding to their peak absorption. The mixed fertilisers have not found much favour with the farmers as the diminishing trends in their production and distribution show. The reason may be the additional cost of mixed fertilisers, which the farmers are unable to pay, attaching at the same time greater importance to nitrogen than others, or possibly to complex fertilisers. There are about 210 mixed fertiliser manufacturers in the country, mostly concentrated in Maharashtra, Gujarat, Karnataka and Tamil Nadu, both in private and cooperative sectors. Because of the extra processing involved, nutrients usually cost more in mixed fertilisers than in the straight materials, and as stated above, this extra cost may have acted nutrients corresponding to their peak absorption. The mixed fertilisers more convenient to handle and use. But the scope of choice of an appropriate ratio out of a wide range of mixed fertilisers is too small to make it easy to meet the nutrient needs of many crops.

48.6.27 The point for consideration is that the economics of the commercially mixed fertilisers have to be demonstrated, otherwise the possibility of promoting them is remote. The mixed fertilisers are

likely to be adulterated by unscrupulous traders and control of their quality is important. Whatever the few advantages mixed fertilisers have, they are outweighed by many disadvantages. As such there is no point in encouraging their manufacture. The single or complex fertilisers are, in fact, available in granular forms, which can be easily mixed according to need and applied.

Soil Amendments

48.6.28 On the basis of pH measurement of surface soils, approximately 49 Mha constituting about 15 per cent of the total land area suffer from varying degrees of acid condition. More than half, (i.e. 29 Mha) of the area is slightly acidic but only 0.5 Mha out of this is under cultivation. The benefits of liming acid soils insofar as agricultural production is concerned are well appreciated and extensive data are available with regard to the degree of liming under varied soil conditions for optimum results. The common liming materials are calcite, dolomite, limestone, cement waste, precipitated chalk available as byproduct of ammonium sulphate manufacture, basic slag from steel industry and paper mill waste. Ten mesh fine powders of the liming materials are just suitable for acid soils. On the basis of extensive work carried out with Bihar acid soils, rough calculations have been made of the requirement of agricultural lime for various acid zones. On the basis of these calculations it is estimated that about 10 quintals on an average will be necessary for every hectare of acid soil. Experiments further show that soils limed once in five years can carry a succession of crops through that period.

48.6.29 It has been estimated that the total area of land affected by different degrees of salinity and alkalinity is about 7 Mha. In the absence of a systematic soil survey and classification it has not been possible to apportion the areas which suffer from saline, saline-alkali and alkali conditions. It is universally recognised that gypsum is an effective amendment for the amelioration of alkali condition of soil. Some more costly ameliorants are sulphuric and nitric acids, aluminium sulphate, ferrous sulphate, sulphur, calcium chloride and lime-sulphur (calcium polysulphide). Fortunately, the natural sources of gypsum in India are quite abundant and may prove more economical for agricultural purposes than others, provided reclamation projects ensure water and drainage, and considerable precautions are taken to prevent reversion to the original condition. Even low grade gypsum, unusable for ammonium sulphate manufacture and plaster of Paris can be used effectively for reclamation. The value of basic slag as a liming

material and as fertiliser obtained from Indian steel industry is poor in the content of phosphorus unlike that from West European countries and USA. Its fertilising value is, therefore, low but it has proved to be a good liming material. The total quantity of basic slag annually available in India from different steel mills is approximately 1.5 million tonnes. Over the years several million tonnes have accumulated creating problems of disposal. Indian basic slag has not been put to agricultural use due to (a) low content of phosphorus, and (b) difficulty in grinding the hard slag to specified size of 70-80 per cent passing through 100 mesh sieve. The fineness is a major factor in causing even diffusion of the material within the soil. As already mentioned the merit of basic slag lies mainly in its capacity to neutralise acid soils, but unless the fineness is such as to allow 70-80 per cent to pass through 100 mesh sieve, even as a liming material it is of little interest. It is possibly within the technological competence of steel factories to produce finely powdered basic slag. The additional cost involved could be met if its sale and hence disposal are assured.

48.6.30 At the Indian Agricultural Research Institute an evaluation of indigenous basic slag for crop production was made. It has been reported that P_2O_5 available per year from this source is around 54,000 tonnes. Apart from P_2O_5 it will supply an equivalent of 1.4 million tonnes of calcium carbonate. Besides the above, basic slag is well supplied with secondary and minor elements, like Ca, Mg, S, Mn, Cu, etc. The application of basic slag on the basis of 80 Kg P_2O_5/ha corresponds to an addition of 1,200 Kg CaO/ha and thereby reduces the lime requirement of acid soils to about one-third of its original value.

48.6.31 The grinding of basic slag to the required particle size costs Rs. 66/- per tonne when the operation is on a small scale as has been experimentally found at the National Physical Laboratory. The cost may considerably be brought down when large scale operation is taken up. Cost of transport, storage, bagging and marketing would add up to the overall cost of the material before being made available to the farmers. In view of the dual benefits derived from application of basic slag in acid soils, it is presumed that it would be economical to process the material for agricultural use. Incidentally, the iron and steel mills are located either in the acid soil regions or nearby areas. The situational advantage will reduce the transport cost. It is recommended that the benefits of basic slag in acid soils are demonstrated and grinding facilities are developed under the auspices of iron and steel manufacturing agencies for making use of this valuable waste material for agricultural production.

7 FERTILISER DOSE

48.7.1 With increased knowledge of soil plant behaviour and understanding of requirements of nutrients by the crops, it has been possible to identify the agroclimatic areas where particular crops can be grown successfully. The factors involved in the most efficient use of fertilisers are (a) the nutrient needs of the crop; (b) crop's ability to extract the required nutrients from the soil; (c) the inherent capacity of the soil to provide the nutrients in a readily available form; and (d) loss by leaching and other processes. The optimum dose of fertiliser depends on consideration of the above factors, provided the usual agronomic requirements are met. A large amount of information on fertiliser application for crop production is provided by simple fertiliser trials in research farms and in the cultivators' fields and model agronomic experiments. Based on the data collected from these sources, generalised fertilisers recommendations have been drawn up by the States for various crops in respect of different administrative units of agroclimatic regions. However, fertiliser doses have to be adjusted taking account of residual effects, and crop rotation involving leguminous crops in a multiple cropping schedule.

48.7.2 A scrutiny of the data available on the recommended doses of fertilisers for various crops gives the general impression that the doses of fertiliser applied by farmers rarely approach the recommended ones. The farmers in the rainfed areas in particular are guided by the calculation of risks of crop failure in not applying the full doses of fertilisers. Even in irrigated or assured rainfall areas, where the risk is less, the availability of fertiliser becomes the limiting factor.

48.7.3 The optimum use of fertilisers is dependent on a large number of variables including soil, climate, water availability, management, balanced use of other components of the input, package, and the cost of crops and fertilisers. Whereas soil tests are considered essential for recommending the optimum dose of fertilisers, the experiments for recommending the doses are hardly based on prior soil tests. The soil testing and fertiliser trials have unfortunately run parallel, even though for the sake of deriving full benefits of each, coordination is called for. Two other economic situations should be recognised, namely, (a) one in which maximum profit per hectare is derived from fertilisation, and (b) another in which maximum return is obtained per rupee invested in fertilisers. The fertiliser trials should be so designed as to enable isolation of these two situations and to make separate recommendations for each.

48.7.4 The generalised recommendations of fertiliser doses for the various crops in an administrative unit and agroclimatic region would be more useful for programming fertiliser despatch to the potential areas of consumption. For a more accurate scheduling of dose from one field to the other in an agroclimatic region, soil test together with response data should be a better guide.

Economics of Fertiliser Use

48.7.5 It has been conclusively shown that the use of phosphate with nitrogen not only yields more but is more economical both with local as well as high yielding varieties. Some recent data obtained with high yielding varieties of paddy and wheat are given in Table 48.11.

TABLE 48·11

Response of Rice and Wheat to N, NP and HPK[1]

District	Variety	No. of trials	Average yield of untreated plot kg/ha	Response (yield increase) to		
				120 kg N/ha	120 kg N+60kg P_2O_5/ha	120 kg N+60kg P_2O_5+60kg K_2O_5/ha
1	2	3	4	5	6	7
			Rice			
Shahabad	IR-8	117	1962	1494	2069	2487
Karnal	,,	67	1795	1510	2205	2265
Cuttack	,,	23	2052	1119	1580	1640
Varanasi	,,	79	2027	1106	1440	1640
Raipur	,,	119	2882	1137	1912	2221
			Wheat			
Ludhiana	C306	59	1932	635	1556	1383
Hoshangabad	Hy-65	124	1312	1148	1977	2070
Karnal	C306	57	2177	1068	2226	1496
Kanpur	K-68	85	1814	917	1282	1516
Shahabad	NP-884	164	1311	1185	1631	1844

48.7.6 Table 48.12 shows further how the net returns improve as a result of balanced application of fertilisers to wheat (*Kalyan Sona*) on cultivator's fields.

[1]. Indian Farming, 1972, 22(5), p 22.

TABLE 48.12

Percentage of Cases falling in Different Economic Categories

Economic category	Ludhiana district (114)* alluvial soil			Hoshangabad (249)* black soil			Karnal (124)* alluvial soil		
	N	NP %	NPK	N	NP %	NPK	N	NP %	NPK
net return/ha									
less than zero	19	1	3	4	2	1	2	—	—
1-500 rupees	33	9	8	27	4	4	17	7	6
501-1,000 rupees	32	18	27	36	13	11	34	19	25
Over 1,000 rupees	16	72	62	33	81	84	47	74	69

*Number of trials

48.7.7 Soils in the dryfarming areas are generally low in nutrients. In fact, even the meagre moisture supply through rainfall could be profitably and efficiently used for crop production, if imbalances in nutrient status of these soils are corrected through judicious fertiliser use. Experiments in research stations and trials on cultivator's fields carried out during the last 2 to 3 years under the All India Coordinated Research Project on Dryland Agriculture and All India Coordinated Agronomic Experiments Scheme have shown conclusively that a balanced use of NPK enhanced the water use efficiency in dryfarming areas. If balanced fertiliser use is coupled with other practices such as quality seeds of high yielding varieties, water harvesting, management practices etc., cultivation of crops in dry farming areas could result in economic betterment of farmers.

48.7.8 Trials conducted on cultivators' fields (1969-70) showed that both hybrid and local maize respond to N but the magnitude of response was more in the presence of balanced NPK fertilisers. However, the response per unit of nitrogen was maximum in the treatment $NH_{60}P_{30}$. During 1970-71, the experiments conducted in Hoshiarpur and Ambala also revealed that NP combination gave the maximum response. The experiments on cultivators' fields on wheat were conducted in Allahabad and Ambala on alluvial soils and in Jabalpur district on black soils for two years and in Hoshiarpur and

[1] Indian Farming 1972, 22(5), p. 23.

Gwalior districts for one year. According to these experiments, the best results were obtained with a balanced application of $N_{50}P_{25}K_{25}$, which gave not only higher response but also the highest net return per hectare. It is interesting to note that $N_{25}P_{25}$ was superior to N_{50}. An economic evaluation of the data on the responses of high yielding wheat varieties obtained under the All India Coordinated Agronomic Experiments Scheme has shown that the net return from the use of fertilisers decreases in the following order:

$$N_{120}P_{60}K_{60} > N_{120}P_{60} > N_{60}P_{30} \gtrsim N_{120} \gtrsim N_{60}.$$

This shows that nitrogen combined with phosphate is more profitable than nitrogen alone. In view of fertiliser shortage and limited resources of the cultivators the combination $N_{60}P_{30}$ is less costly but being more efficient than N_{120} is preferable to N_{120} P_{60}. Further, phosphate in combination with nitrogen improves the physical condition of the soil thereby contributing to soil and moisture conservation.

48.7.9 The data presented in the foregoing pages conclusively prove that the use of NP and NPK is superior to N alone. The doses referred to above are applicable in a general way. The variations from the general recommendation will depend primarily on soil test and on the comparative values in particular cases of the maximum yielding dose and the economic dose of fertilisers. Similar data given in Table 48.13 using various NPK combinations are available from experiments conducted at IARI with Sonora 64.

TABLE 48·13

Response and Economic of Sonora 64 to NP Combinations[1]

Level of nitrogen kg/ha	Associated treatment kg/ha	Yield kg/ha	Increase over control kg/ha	Response to added nitrogen kg grain/kg N	Net* profit (Rs/ha)	Benefit cost ratio
99 . .	$P_{75}K_{50}$	5,047	1,457	1·45	798	2·7
	$P_{60}K_{50}$	4,779	1,189	11·8	615	2·5
	$P_{50}K_{25}$	4,760	1,170	11·7	617	2·5
	$P_{50}K_{75}$	4,588	998	8·8	430	1·9
	$P_{25}K_{50}$	4,665	1,075	10·7	556	2·5
50 . .	$P_{25}K_{25}$	4,330	740	14·8	433	3·1
. .	$P_{50}K_{50}$	4,320	730	14·2	354	2.3
149 . .	$P_{75}K_{75}$	4,617	1,027	6·8	263	1·4
	$P_{50}K_{50}$	4,617	1,027	6·8	333	1·6
Control .	P_0K_0	3,590	..	..	..	..

*In calculating net profit and benefit cost ratios, the cost of fertilisers and the value of the grain prevailing at that time were used.

Journal of Post Graduate School, IARI 1969, 132-139.

From the above table, it will be further seen that there are two combinations of the nutrients which are of significance. The combination, N[illegible]$P_{75}K_{50}$, yields the maximum profit (Rs. 798.00) per unit area and is economically optimum under conditions of adequate availability of capital for investment in fertilisers. The combination, $N_{50}P_{25}K_{25}$ shows the highest benefit/cost ratio (3.1) and yields the maximum profit per rupee invested in fertilisers. Under conditions of limited availability of capital as is the case with most of that Indian farmers, they would prefer the latter combination. The practice of fertilisation, if intended to be accepted generally, should therefore aim at fitting into the economic situation of the farmers.

48.7.10 Under the Soil Fertility and Fertiliser Use Project and the All India Coordinated Agronomic Experiments Scheme a very large number of field trials have been conducted with various crops and their varieties on different soil groups and units. They have provided useful information on responses of high yielding and indigenous crop varieties to nitrogen and phosphorus applied alone or in combination, and to potassium in presence of nitorgen and phosphorus under irrigated and dryland conditions. They have also helped in formulating general recommendations of fertiliser use for different soils and agroclimatic regions of the country. Under the project of Coordinated Soil Test Crop Response Correlation Studies, a lot of work on soil fertility evaluation and crop responses on various gradients of available soil nutrients and applied fertilisers has been done. In all the above projects there is a lack of stress on development of models on the economics of fertiliser use to help the farmer, in conformity with his resources, to decide about the optimum level of fertilisation under the prevailing soil and cropping condition. Now that the farmer has become conscious of fertiliser use and does not hesitate in making investment in fertilisers, he would aspire for a reasonable return on the investment. We, therefore, recommend that in all coordinated research programmes and projects considerable emphasis should be laid on the economics of fertiliser use with reference to a particular soil type and crop variety and on evolving improved practices of fertilisation under the prevailing economic situations. The usual practice of fertilisation has so far been based on the concept of a certain dose of fertilisers for a single crop. In view of the fact that most of the fertilisers leave a residue which may be made available for the next crop(s) the concept of single crop fertilisation has given place to that of multiple crop fertilisation where the entire sequence of crops is taken into con-

sideration for the purpose of fixing doses. This concept when taken to its logical conclusion would not only increase the efficiency of fertiliser use but also entail considerable economy.

8 SOIL TESTING AS A GUIDE TO EFFICIENT USE OF FERTILISERS

48.8.1 A very large number of fertiliser trials have been conducted throughout the country under the Soil Fertility and Fertiliser Use Project, All India Coordinated Agronomic Experiments Scheme and by the various State departments of agriculture and agricultural universities in the State/university farms and under field experiment schemes. These experiments have helped in the formulation of fertiliser recommendations in respect of different soil areas or administrative units in different States. These generalised fertiliser recommendations are useful for the purpose of guiding the farmers in the use of fertilisers but they lack in relevance to the prevailing fertility conditions of the farmers' fields. In the same administrative unit there are likely to be a number of differentiated soils having varying conditions of fertility. Even in the same farm there are differences in the fertility status of the soils from one field to the other, depending on the past management and soil properties. It becomes practically impossible to conduct fertiliser experiments in each of the farmers' fields to arrive at reasonably valid fertiliser recommendations. In this context, the development of a rapid chemical method for the assessment of available nutrients in the soils which will be a guide to fertiliser use, is implied. Soil testing is considered to be an essential element in many countries in the evaluation of the nutrient status of soils. The data derived on the available contents of nutrients in soils are useful in recommending economic and efficient use of fertilisers. Results of trials conducted in Stage II villages in the IADP district of Raipur and of trials on hybrid maize in Rajasthan have clearly indicated the extent of economic benefits derived from fertiliser use based on soil tests. An analysis of data obtained at IARI pertaining to 10-year trials conducted on farmers' fields have shown that the profits are about 11 per cent more in case of fertiliser applied on the basis of soil test than when general State government recommendations are used. Soil test, by comparison, costs about 1 per cent of the cost of fertiliser saved. In the light of this information, we emphasised in our Interim Report on Fertiliser Distribution the importance of soil testing in fertiliser application. While recommending fertiliser doses it should be ensured

that they are appropriate for the soil to be used, the crop to be grown and the level of farm management.

Present Status of Soil Testing

48.8.2 While reviewing the work done on soil fertility in relation to the cultivation of various crops in India, Stewart (1947)[1] recommended the carrying out of soil fertility investigations including simple experiments in cultivators' fields, soil surveys and other laboratory investigations. In pursuance of these recommendations, the ICAR initiated a scheme under which a series of 3-plot trials in cultivators' fields were conducted in seven States and this continued over three years. In the light of experience gained, a revised scheme for conducting fertiliser experiments in cultivators' fields was formulated under the 'Soil Fertility and Fertiliser Use Projects'. The programme under the project included (a) soil survey and soil mapping; (b) radiotracer investigations on uptake of phosphorus; (c) agronomic trials for determination of fertiliser responses; and (d) development of rapid soil tests for N, P_2O_5 and K_2O, correlated with crop responses, for drawing up fertiliser schedules. Under item (d) different soil testing methods were assessed at the IARI in respect of their suitability for different soil types. Available nutrient contents in the soil were categorised into three ranges, viz., low, medium, and high, to help interpretation of soil test data and for formulating fertiliser use recommendations.

48.8.3 As mentioned earlier, the need for a soil testing service as a vital part of the expanding fertiliser use programme was recognised by the Government of India and the scheme of 'Expanded Soil Testing Service in India', was initiated under the joint auspices of the Technical Cooperation Mission (United States of America), Government of India and the IARI in 1956, when 16 standard soil testing laboratories with a capacity of analysing 10,000 soil samples per year each were established. Later on 8 more laboratories were added making a total of 24 such laboratories scattered all over the country. Under the IADP programme 9 standard soil testing laboratories with enhanced annual capacity of 30,000 soil samples each were established in the package programme districts, and a few of the original laboratories were also strengthened to 30,000 soil samples each to serve other package districts in which these laboratories were located. A mobile soil testing laboratory was supplied to the IARI under

[1] Stewart, A.D. (1947) Report on Soil Fertility Investigation in India with Special Reference Manuring, Army Press, Delhi.

the original scheme for rendering service to the cultivators on the spot. The State Governments have similarly established a number of soil testing laboratories to strengthen the existing facilities and to render service to the cultivators. In order to supplement the facilities already available, the Government of India initiated a scheme for fabrication of 34 units of mobile soil testing laboratories in 1968 to be distributed to different States for rendering soil testing service to the farmers on the spot. These mobile laboratories are composite in nature, being provided with facilities of laboratory analysis and audio-visual equipments, the latter for the purpose of educating the farmers in recent technological advances in agriculture. In addition to the laboratories set up in the States, the Ministry of Agriculture and Irrigation formulated a scheme to provide supplementary soil testing facilities at block levels. Two hundred soil test kits were supplied to the State Governments. It was further envisaged under the scheme to create employment opportunities to the unemployed or underemployed rural science educated youths. The number of soil testing laboratories and their location as compiled by the Ministry of Agriculture and Irrigation is given in Appendix 48.11. Besides these, there are a number of soil testing laboratories, both stationary and mobile, which have been established by the fertiliser manufacturers and the state marketing federations. At present there are 235 laboratories in the country with an annual capacity of analysing over 3 million soil samples. Even this capacity is inadequate.

48.8.4 The percentage utilisation of the institutional soil testing laboratories in the different zones for the year 1970 and 1971 is shown below in Table 48.14 :

TABLE 48·14

Percentage Utilisation of Capacity of Soil Testing Laboratories

Zone	States	Percentage utilisation of capacity	
1	2	3	
		1970	1971
Eastern	*Assam, Bihar, Orissa, West Bengal, Manipur, Tripura	31·0	43·1
Western	Gujarat, Maharashtra	56·4	82·2

TABLE 48.14 (contd.)

1	2	3	
Southern	Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Pondicherry	75·0	88·8
Northern	Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh	above 100	Above 100
Central	Uttar Pradesh, Madhya Pradesh, Rajasthan, Delhi	71·6	56·0

* Includes Meghalaya, Mizoram, Nagaland & Arunachal.

It will be seen that in the eastern and central zones the utilisation of capacity of soil testing laboratories is very low. Of the various reasons assigned for the poor performance of many of the laboratories the following seem to be important: (a) inadequate laboratory space and staff facilities; (b) frequent instrument failure and lack of facilities for their timely repair; (c) lack of regular water supply and frequent power breakdowns; and (d) irregular flow of soil samples to the laboratory from the extension agency and lack of response on the part of those responsible for collection of soil samples.

48.8.5 Some of the laboratories have not been able to get electric connections to enable them to make use of the electrically operated instruments. The soil testing laboratories have to handle a large number of soil samples per day, as such provision of automatic and time saving devices would enhance their operational efficiency. However. most of them have no such provision. The normal functioning of the laboratories to full capacity is associated with the working conditions of the instruments. Frequent failures of scientific instruments results in nonutilisation of the full capacity. The data compiled from reports of 51 institutional laboratories in the country show the frequency of failure of the different instruments/apparatus as below:

Name of instrument/apparatus	Frequency of failure
1. Flamephotometer	One out of every 3 labs
2. Colorimeter	One out of every 8 labs
3. pH meter	One out of every 4 labs
4. Miscellaneous, *viz.*, Centrifuge, conductivity bridge, water distillation plant, oven, transformer, multiple dispensing unit, air compressor, voltage stabiliser etc.	One out of every 6 labs

48.8.6 Some of the defects in the instruments/apparatus may be of minor nature and others more complicated. In the first case the defects can be located and rectified easily in the laboratory itself by paying a little attention provided the mechanism of the instruments is known to the operator. In the latter case, the instruments may require attention of experts preferably with knowledge of electronics. Due to ignorance of operators about the instruments, even minor defects are not rectified resulting in nonutilisation of capacity. Even a heavy loss is suffered on account of rejecting a costly instrument and subsequently replacing it with a new one. It is suggested that the incharge of the soil testing laboratories must be given training in instrumentation, so that maintenance and minor repairs of instruments may be attended to in the laboratory itself. At the IARI there is an instrumentation cell, where repairs and servicing of instruments are done. The IARI or the agricultural universities should be able to develop a short period training programme for imparting training in instrumentation and repair and maintenance of different instruments/apparatus used in soil testing laboratories. The agricultural universities, in addition, may be entrusted with the maintenance of a minimum standard of performance of the soil testing laboratories. The State of Karnataka has developed a mobile instrument repair van. This van visits different soil testing laboratories situated in the different posts of the State and renders repairs services on the spot. In case of complicated troubles the instruments is replaced from the stock and the damaged one is taken away for detailed examination and repair. It is suggested that other State Governments may develop such facilities, so that soil testing laboratories in their States are not allowed to suffer from frequent instrument failure and lack of repair facilities.

48.8.7 In the stationary laboratories the flow of soil samples has varied considerably from time to time due to various reasons, one of them being cultivators not taking adequate interest in the service. It has been realised that not more than 5 to 10 per cent soil samples come to the laboratories direct from the farmers. This shows that no definite impact on the cultivators has been created. As a result, there has been an attempt on the part of the different State departments of agriculture to instruct the extension officers including BDO's, AEO's, VLW's for collecting soil samples from the cultivators' fields and sending them to the laboratories for analysis. The accuracy of soil sampling under this procedure has been questioned and the results of the analyses often doubted. For creating interest in the cultivators and motivating them in getting soils tested for better fertiliser use, cultivators may be involved in this service programme. The mobile soil testing labora-

tory developed by the Directorate of Extension, Ministry of Agriculture and Irrigation has given a good account of service to the cultivators on the spot. The rural visits created immense interest in the farmers for getting soils analysed for effective and efficient use of fertilisers. The State departments of agriculture should continually evaluate the performance of the mobile laboratories in their areas. In developed countries the farmers are conscious of getting their soils analysed and thereby making economical use of fertilisers. The bulk of Indian farmers are ignorant of the various facilities that are available for soil testing. As the farmers' involvement in soil testing increases, the message would quickly spread to remote villages.

48.8.8 In each of the States there should be a Central laboratory to function as a control laboratory. This laboratory will be responsible for quality control of the soil testing work by circulating check samples in the different laboratories of the State and will from time to time verify the efficiency of fertiliser recommendations issued from the laboratories. At the State headquarters level there should be an officer of high rank to coordinate the work of different regional laboratories in the State and to render all necessary help for their efficient working. The fertiliser manufacturers and marketing federations would usually tend to concentrate on promoting their own products which may not conform to balanced fertilisation. In that eventuality, it would be necessary for the State departments of agriculture to have a close look into the work of their soil testing laboratories so that the developed facilities are not utilised to the detriment of balanced use of fertilisers. Further. the institutional and private soil testing laboratories should demarcate the areas of operation in order to avoid unnecessary overlapping.

48.8.9 During the Fifth Plan it is proposed to establish 150 more stationary laboratories at district levels and 100 mobile soil testing laboratories. With this, all the districts of the country will be covered by one stationary soil testing laboratory each. The proposed expansion programme should, however, be preceded by the full utilisation of the existing facilities and improvement in quality of services. The stationary soil testing laboratories, it must be admitted, have limited scope for making direct contact with the tillers of the land, appreciating their fertility problems and advising them adequately on remedial measures and fertiliser use. It was envisaged that a number of ABC* demonstration trials would be carried out under the auspices of each of the soil testing laboratories to acquaint the farmers with

* A—Farmers' usual practice; B—Fertiliser use based on soiltests; C—Fertiliser use as per general recommmendations of the State Department of Agriculture.

the usefulness of soil testing for fertiliser use. A certain percentage of soil testing recommendations were also to be followed up on the farms. Adequate attention should be given to the programme of demonstration trials.

Evaluation of Soil Test Work

48.8.10 The Programme Evaluation Organisation of the Planning Commission in a report on the evaluation of high yielding varieties programme for rabi 1968-69 made some observations relating to soil testing as follows :—

(i) There was no appreciable increase in the number of soil samples sent for analysis in the blocks where the study was carried out.

(ii) The number of sample participants reporting soil test was negligible.

(iii) In some blocks soil test results were simply filed after obtaining the signature of the VLWs that the results had been duly noted by them.

(iv) In some cases the results were received after the sowings of rabi season had been completed.

(v) In one of the selected blocks for study it took considerable time for the samples to reach their destination, and much worse, no results were communicated either to the Block Officer or to the cultivators.

(vi) Generally, the soil testing programme was reported to be very weak in the areas where the study was undertaken.

48.8.11 The time lag between receipt of soil samples and issue of recommendations from the laboratory ranges between 15 days and 4 months. Such a situation discourages the farmers about the soil testing programme as no benefits are likely to accrue from recommendations received after the crop is half way through. A large number of fertiliser demonstrations and trials are being conducted by different agencies, namely, the State departments of agriculture and fertiliser manufacturers. It is necessary to coordinate such demonstration trials so that they are widely spread out. For this purpose, a Coordination Committee under the chairmanship of the Director of Agriculture may be formed in which all the participating agencies will be represented. This Committee will draw up the annual programmes specifying the areas of operation for the different agenices, ensure fertiliser use based on soil test results, and evaluate the overall effectiveness of the programme.

Soil Test - Crop Response Correlation

48.8.12 India has a fairly long history of soil fertility research Under the Technical Cooperation Mission Scheme (USA) of Soil Fertility and Fertiliser Use, the IAR took up soil test-crop response correlation studies with various types of soils collected from different agro-climatic regions. In these studies several soil testing methods were evaluated and the method which gave the best correlation in the pot culture studies on wheat and rice were selected. Percentage yield response to fertilisers was taken as a criterion for working out the correlation with soil test values. It was observed that for nitrogen the potassium permanganate method; for available phosphorus, Olsen's method (in neutral to alkaline soils) and Bray No. 1 method (in acidic soils); and for potassium, ammonium acetate method gave the best correlation. Besides the selection of the methods suited to Indian soils, these studies enabled categorisation of the available nutrient contents in relation to each of the selected methods for N, P and K into three group ranges, namely, low, medium and high. The limits of the available nutrient contents for different categories were originally worked out for two local crops, namely, rice and wheat and for a limited number of differentiated soils. This information is thus limited in its applicability. The soil test-crop respons correlation studies have not been carried out in the States to any extent and the data are scantly. Due to lack of systematic data on soil test-crop response correlations under different agroclimatic conditions, the generalised fertiliser recommendations developed as a result of fertiliser experiments in different States under various agronomic schemes were adopted as basis for making fertiliser recommendations. A deviation up to about 50 per cent on either side of the generalised recommendation was usualy considered adequate for framing fertiliser recommendations based on the observed soil test values. These *ad hoc* recommendations had no serious economic impact in case of local varieties of crops which required low doses of fertilisers. With the introduction of high yielding varieties of crops which require heavy doses of fertilisers the above *ad hoc* recommendations may adversely affect the farm economy. The soil testing programme in the country has gone for more than fifteen years but no fertiliser schedule for different soil classificational units under different agroclimatic conditions for the various crops grown in the country has been worked out based on results of soil test-crop response correlation studies.

48.8.13 In view of the deficiencies in the soil test-crop response correlation studies, an All India Coordinated Scheme for Investigation on Soil Test-Crop Response Correlation was initiated at the IARI

under the auspices of the ICAR in 1967. The project is in operation in the different agroclimatic and soil regions. The agricultural universities and research institutes of the States concerned are cooperating in the programme. The principle underlying the working of the scheme is to get as large a variation as possible in soil fertility in one field in the same location where the field experiment is conducted, so that the relationship between the yields and soil fertility levels can be evaluated without interference of other factors, environmental or otherwise, influencing crop growth. The scheme has the advantage of eliminating the variability in different growth factors which may come in the way of the experiment, if they would have been carried out in similar soils of different fertility gradients under different climatic conditions.

48.8.14 Some results of practical importance are claimed to have emerged from the soil test-crop response correlation studies. The analysis of the followup trial of targeted yields of wheat conducted at Powarkheda, Ludhiana, Bawana, Jharoda and Delhi have shown that it is possible to achieve the yield targeted within 10 per cent error when the fertiliser doses are applied according to the principle of balanced nutrition. In all these cases the profitability from the use of fertiliser for targeted yields has always been more than that from the recommended dose. Targeting for lower yield levels under constraints of fertiliser availability is claimed to be more profitable than arbitrarily slashing the recommended dose by 50 per cent. The analysis of the followup experiments comparing the most profitable dose according to the adjustment equation with the recommended dose has shown that in all cases the farmer ensures maximum returns per hectare. The adjustment equations that have been arrived at different centres for different crops and varieties are many. Such a situation is not conducive to soil testing laboratories doing routine analysis to formulate fertiliser recommendations with the desired rapidity. In working out the amounts of fertilisers to be applied to achieve targeted yield three things are required to be known; (a) average amount of nutrients necessary to produce one quintal of grains; (b) contribution from the soil as determined by soil tests; and (c) the contribution from the fertiliser. In applying the adjustment equations it is assumed that targeted yields and fertiliser requirements are linearly related falling on the linear portion of the response curve. Various workers have shown that the most efficient and economic dose of fertilisers usually falls on the curvilinear portion of the response curve. It thus becomes difficult to reconcile the targeted yield concept with the optimum fertiliser doses. Moreover,

various other biological and chemical factors, including the environmental, combine to regulate plant growth and finally determine the yield of crops. These factors are difficult to quantify. In such a situation it is not possible to visualise how they would always react and interact resulting in a predicted yield, based simply on soil tests. The soil system is so heterogeneous that even in the same field there is likely to be variation in its chemical, physical and biological properties. A soil testing laboratory has hardly any scope for such sophistication as to take care of all these properties and factors referred to above.

48.8.15 The scheme of soil test-crop response correlation has been in operation for quite some time and considerable data have accumulated for a number of agroclimatic and soil regions. These data should be made use of for solving the fertility problems of these regions and to draw up fertiliser schedules for varied crops. The officials of the soil testing laboratories of the regions should be adequately trained so that they are able to make specific fertiliser use recommendations for different crops and soils. There should be a programme of revision of fertiliser schedules as new knowledge develops.

48.8.16 A rapid method for correlation of soil test analysis with crop response data has been developed under the International Soil Testing Project of the North Carolina State University, wherein 'critical soil test level' is found out by a plastic overlay having a pair of intersecting perpendicular lines. The method of finding out the critical level by the above procedure avoids elaborate computation. Even though it does not provide the basis for quantified fertiliser recommendations, it permits the statement. "Below the critical level the probability of economic response is high, while above this level there is a small chance of obtaining a large response." In the Latin American countries this method has been successfully employed after due pot and field studies for recommending economic fertiliser doses for important crops grown in those countries. Under the All India Coordinated Agronomic Experiments Scheme the same method has been used successfully. Results from 63 trials on cultivators' fields with wheat (Kalyan Sona) in Kanpur district have shown good relationship between the yield response to applied phosphorus and potassium and soil test values for phosphorus and potassium, and also with the other soil characteristics. It is worthwhile giving a fair trial to the above method so that specific fertiliser use recommendations could be worked out without much loss of time.

Soil Fertility Maps

48.8.17 Since the initiation of the soil testing programme in 1956, considerable expansion in the facilities for soil testing has taken place. A few million soil samples have been analysed. Most of the laboratories have made use of these data in the preparation of soil test summaries in respect of N, P_2O_5 and K_2O on administrative unit area basis, indicating the percentages of soil samples falling in different categories, i.e., low, medium and high. Some of the laboratories have taken district as a unit, others have taken blocks or Panchayat Samitis as the unit for working out these summaries. The nutrient indices have been worked out based on these summaries. The method of working out the nutrient index is to multiply the percentages in the categories of 'low', 'medium', and 'high' by factors 1, 2 and 3 respectively and the sum of these in respect of a unit area is divided by 100 to give the nutrient index value of a particular nutrient. The average nutrient index values of less than 1.5 were considered low; those between 1.5 and 2.5 were taken as medium; and the values greater than 2.5 were taken as high. On the basis of these values the fertility index or soil fertility maps were drawn up. Under the auspices of Indian Agricultural Research Institute, soil fertility maps of India have been drawn up in 1960, 1963 and 1969 after compilation of the data of the different laboratories and grouping them districtwise. As more data accumulated, the map was revised. The maps prepared in 1960 and 1963 made use of nutrient index ranges mentioned above for the purpose of mapping. The map prepared in 1969 has deviated from the above ranges. In this map a district with an index value of less than 1.67 is considered low, between 1.67 and 2.33 as medium and above 2.33 as high for the relevant nutrient. It has been argued that in selecting these ranges undue weightage to the medium category has been avoided. The map is a composite one, prepared by the superimposition of N, P_2O_5 and K_2O maps. Different kinds of representation for each of the three nutrients have been used in the preparation of the composite Map[1], which covers only 181 out of 338 districts, for which suitable information is available.

48.8.18 The district, an administrative unit, considered for mapping the fertility index would appear scientifically less sound as several soils having different characteristics often occur in the same district. It would appear worthwhile to prepare such maps on soil unit basis, so that other characteristic of the different soil units modifying the crop growth could be related to soil fertility to enable a better inter-

[1] Ramamoorthy, B. & Bajaj, J.C. (1969) Soil Fertility Map of India, IARI, New Delhi.

pretation of soil test data and formulation of fertiliser use recommendations. The soil fertility map of India prepared under the auspices of IARI in 1969 when compared with the soil map of India has shown certain interesting associations between the soil groups and fertility classes. Of course, the district as unit has an advantage for programming fertiliser distribution which can be more effectively taken care of by superimposing the two maps. This procedure should be adopted by the States while revising their soil fertility maps. Such maps would be more scientific and also serve the administrative purpose and may be displayed at the fertiliser selling centres. These maps would enable the farmer to decide on the requirements of his fertilisers and their combination, even if specific information on soil tests for his farm soils is not available. Extension personnel or the retailers may guide the farmer on the requirement of fertilisers and their combination for his crops. This would help in promoting balanced use of fertilisers for varied crops. The fertiliser mixture manufacturers can make use of these maps in the formulation of their grades for different areas and for different crops. It may help in programming distribution of fertilisers in such proportions as indicated by the fertility index maps. In view of the possible benefits derivable from the use of fertility maps, it is recommended that they should be prepared by the adoption of improved methodology. For proper assessment of the fertility needs of each administrative unit and efficient fertiliser distribution they have to be superimposed on administrative unit maps.

9 SUMMARY OF RECOMMENDATIONS

48.9.1 The following is a summary of important recommendations made in the text of this chapter :—

Plant Nutrients

1. Algal fertilisers deserve to be exploited to the fullest extent.
(Paragraph 48.2.5)

2. For success in modernised farming, specially with high yielding varieties, an efficient and balanced use of fertilisers and manures is imperative. A correct measure of nutrient balance is to be based on the ratio in which they appear in fertiliser recommendations resulting from field trials instead of the ratio of consumption, as is usually done.
(Paragraphs 48.2.10 to 48.2.19)

3. For making assessment of fertiliser requirement for achieving certain levels of agricultural production the exercise should be more realistic and related to the actual performance in the field.

(Paragraphs 48.3.1 to 48.3.12)

Factors Affecting Efficient Use of Fertilisers

4. If adequate safety measures are taken, anhydrous ammonia should, under suitable circumstances, replace the solid nitrogenous fertilisers in our country. Before venturing its large scale application, which involves new technologies and techniques both in the field and in handling from the factory to the distribution end, a series of experiments need to be undertaken. Because of the risks involved in handling anhydrous ammonia, its use can preferably be promoted through well organised custom services.

(Paragraphs 48.4.5 to 48.4.7)

5. High analysis phosphates like the polyphosphates promise certain advantages and, therefore, deserve attention as to their performance under different soil and climatic conditions.

(Paragraph 48.4.15)

6. Constant watch should be kept in respect of micronutrient deficiencies under the intensive agriculture and suitable methods are developed for incorporating them.

(Paragraphs 48.4.18 to 48.4.19)

7. Methods of application of fertilisers and their efficient utilisation have to be considered in relation to the root systems of crops and their pattern of development in the soil medium. Sufficient information on these aspects is wanting. Appropriate research work should be initiated in this field.

(Paragraph 48.4.20)

8. Considerable controversy exists in regard to the efficacy of foliar fertilisation with urea and also its economics. As leaf characteristics have a definite role to play in the absorption of nutrients, the physiological behaviour of the plant leaves needs to be studied before coming to a definite conclusion about the efficiency of foliar fertilisation with urea or such other fertilisers.

(Paragraph 48.4 21)

Soil Organic Matter and Organic Manures

9. Bulk and consequent cost of transport are handicaps in the application of processed organic wastes to the field. Suitable methods of reducing bulk by chemical and microbiological or other methods need to be evolved. Enrichment of organic wastes with nitrogen and

phosphates will considerably enhance their manurial value.

(Paragraph 48.5.4)

10. The programmes of development of organic manures by the Ministry of Agriculture and Irrigation in which urban and rural composts, sewage and sullage etc. are being mobilised are attempts in the right direction. The manner in which the urban wastes are processed determines its manurial value which can be enhanced by suitably treating them with ammonium and phosphatic compounds.

(Paragraph 48.5.5)

11. Centres for utilisation of sewage and sullage should multiply and develop as a continuing venture.

(Paragraphs 48.5.5 to 48.5.7)

12. By introducing gobar gas plants the energy requirements of the farmer's houshold can be met, retaining the manurial value of the dung. Rural population should be given adequate technical guidance and help in making use of this innovation.

(Paragraph 48.5.8)

Chemical Fertilisers and Soil Amendments

13. In a vital sector like fertilisers, the shortfall in indigenous production is of disastrous consequences. All available resources should be mobilised to reduce a big shortfall, particularly in the field where the country's technological capability is of no mean order.

(Paragraph 48.6.1)

14. In selecting coal as feedstock, the question of economics has to be weighed in its totality, in which indigenous availability of coal and returns in terms of employment in related sectors of mining and accessory industries have to be taken into consideration. For a long term plan of developing nitrogenous fertiliser capacity, there is no alternative to indigenous production.

(Paragraph 48.6.9)

15. It would be prudent to avoid, as far as possible, sulphur in the indigenous manufacture of phosphatic fertilisers.

(Paragraph 48.6.5)

16. There is controversy over the ratio of water soluble to citrate soluble forms of phosphate in regard to efficiency. Extensive field experimentation should be taken up in verification of the efficiency of the above two forms and their optimum ratio in crop production under varied soil and climatic conditions.

(Paragraphs 48.6.7 to 48.6.8)

17. Geological explorations should be intensified on an extensive scale in search of new sources of phosphorus.

(Paragraph 48.6.10)

18. In respect of potash, it is suggested to explore the possibility of utilising bittern of salt industry and of developing chemical processes to make potassium in potash feldspar and mica available for fertilisation.

(Paragraph 48.6.11)

19. Some kind of recycling process may be exploited to make the locked up phosphate and potash in the soil, both native as well as from added fertiliser sources, available to crops.

(Paragraph 48.6.12)

20. A Committee of analytical and agricultural chemists drawn from IARI, agricultural universities, State Departments of Agriculture and fertiliser industry should go into the various details in respect of all fertilisers to suggest suitable methods of analysis for general acceptance throughout the country. This Committee will also review the methods at intervals.

(Paragraph 48.6.13)

21. The fertiliser industry should aim at developing technology for meeting requirements of high analysis fertilisers, straight and complex/compound, so that materials of higher efficiency could be made available to the farmers at a low cost.

(Paragraph 48.6.15)

22. Soil testing data and fertility index map should help in channelising the fertiliser distribution, so that proper grades are available to the farmers in relation to their soils and crops.

(Paragraph 45.6.23)

23. The recommendations made on quality control of fertilisers in our Interim Report on Fertiliser Distribution are reiterated.

(Paragraphs 48.6.24 and 48.6.25)

24. Necessary facilities for grinding basic slag to proper mesh size should be developed under the auspices of iron and steel manufacturing agencies for making use of this valuable waste material for crop production.

(Paragraph 48.6.30)

Fertiliser Dose

25. Farmers are found rarely to apply the recommended doses of fertilisers. The reasons for this should be investigated in order to take remedial measures.

(Paragraph 48.7.2)

26. Two situations are recognised in farming, namely, (1) one in which maximum profit per hectare is derived from fertilisation, and (2) another in which maximum return is obtained per rupee invested in fertilisers. The fertiliser trials should be so designed as

to enable isolation of these two situations and to make separate recommendations for each.

(Paragraph 48.7.3)

27. The generalised recommendation of fertiliser doses for different crops in an administrative unit and agroclimatic region would be more useful for programming fertiliser despatch to potential areas of consumption. For a more accurate scheduling of dose from one field to the other in an agroclimatic region, soil tests backed by research experience on crop response should be a better guide.

(Paragraph 48.7.4)

28. In dryfarming areas balanced and judicious fertiliser use is called for in order to utilise efficiently available soil moisture.

(Paragraph 48.7.7)

29. All coordinated research programmes and projects should lay considerable emphasis on the economics of fertiliser use not only with reference to a particular soil type and a single crop but also to the sequence of crops in multiple crop fertilisation.

(Paragraph 48.7.10)

Soil Testing as a Guide to Efficient Use of Fertilisers

30. The efficiency of soil testing should be improved, so that the predictability of crop response to fertiliser use based on soil tests is enhanced. While recommending fertiliser doses, it should be ensured that they are appropriate for the soil to be used, the crop to be grown and the level of farm management.

(Paragraph 48.8.1)

31. Necessary steps should be taken to improve the working efficiency of soil testing laboratories by keeping the measuring instruments in order and introducing automatic and time-saving devices.

(Paragraphs 48.8.3 to 48.8.6)

32. For creating interest in the cultivators and motivating them in getting their soils tested for better fertiliser use, the cultivators should be involved in the service programme.

(Paragraph 48.8.7)

33. In each state there should be a central laboratory to function as a control laboratory. There should be an officer of high rank at the state headquarters to coordinate the work of the different laboratories and to render necessary help for efficient working of the laboratories.

(Paragraph 48.8.8)

34. The State Department of Agriculture should continually evaluate the performance of the mobile soil testing laboratories. It

should have a close look into the working of the laboratories set up by the fertiliser manufacturers, marketing federations and other private agencies so that the developed facilities are not utilised to the detriment of balanced use of fertilisers. The institutional and private soil testing laboratories should demarcate the areas of operation in order to avoid unnecessary overlapping.

(Paragraphs 48.8.7 to 48.8.8)

35. Attempts to increase the number and capacity of soil testing laboratories should be preceded by a full utilisation of the existing facilities and improvement in quality of service

(Paragraph 48.8.9)

36. The demonstrations and trials of fertiliser use based on soil tests being conducted by different agencies should be widely spread out. A Coordination Committee under the chairmanship of the Director of Agriculture may be formed in each State in which all the participating agencies will be represented. This Committee will draw up an annual programme, specifying the areas of operation for the different agencies, ensure fertiliser use based on soil tests and evaluate the effectiveness of the programme.

(Paragraph 48.8.11)

37. Soil test-crop response correlation studies should be a continuing process in order to guide the soil testing laboratories in formulation of more and more reliable and reasonable fertiliser use recommendations. The data collected for various agroclimatic and soil regions should be analysed to draw fertiliser schedules. The officials of the soil testing laboratories should be adequately trained in various aspects of soil testing including interpretation of data so that they are able to make specific fertiliser use recommendations for different crops and soils. There should be a programme of revision of fertiliser schedule as new knowledge develops.

(Paragraph 48.8.15)

38. The method developed under the International Soil Testing Project of the North Carolina State University may be tried to find out if it could be more efficiently and speedily used in India in recommending fertiliser doses.

(Paragraph 48.8.16)

39. Soil fertility maps should be prepared by adopting improved methodology. For proper assessment of the fertiliser needs of each administrative unit and efficient fertiliser distribution they have to be superimposed on administrative unit maps.

(Paragraph 48.8.18)

APPENDIX 48.1

Paragraph(s 48.2.2 and 48.3.2)

Nutrients Removed by Foodgrain Crops—Actual and Projected Production*

Foodgrain	Production 1970-71	Production 1973-74	Peak targetted production 1978-79	Average removal of nutrients (kg/tonne of grain yield)			Removal of nutrients (million tonnes)											
							1970-71				1973-74				1978-79 (Target)			
				N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)
	(million tonnes)																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
paddy .	42.2	43.7	54.0	20.9	8.6	44.8	0.88	0.36	1.89	3.13	0.91	0.38	1.96	3.25	1.13	0.54	2.42	4.09
wheat .	23.8	22.1	38.0	27.2	15.0	36.0	0.65	0.36	0.86	1.87	0.60	0.33	0.80	1.73	1.03	0.57	1.37	2.97
jowar .	8.1	9.0	11.0	46.3	16.0	77.0	0.38	0.13	0.62	1.13	0.42	0.14	0.69	1.25	0.51	0.18	0.85	1.54
bajra .	8.0	7.1	8.0	33.5	12.2	112.6	0.27	0.10	0.90	1.27	0.24	0.09	0.80	1.13	0.27	0.10	0.90	1.27
maize .	7.5	5.6	8.0	42.4	17.5	89.0	0.32	0.13	0.29	0.74	0.24	0.10	0.22	0.56	0.34	0.14	0.31	0.79
other cereals	7.0	6.3	7.0	21.9	11.7	50.7	0.15	0.08	0.35	0.58	0.14	0.07	0.32	0.53	0.15	0.08	0.35	0.58
pulses .	11.8	9.8	14.0	57.9	7.1	9 .5	0.68	0.08	0.11	0.87	0.57	0.07	0.09	0.73	0.81	0.10	0.13	1.04
total .	108.4	103.6	140.0				3.33	1.24	5.02	9.59	3.12	1.18	4.88	9.18	4.24	1.71	6.33	12.28
							1:0.4:1.5				OR 14:0.4:1.6				1:0.4:1.5			

* Based on total contents of nutrients in the harvested plant parts above ground including grain and straw.

APPENDIX 48.2

(Paragraphs 48.2.2 and 48.3.2)

Nutrients Removed by Non-Foodgrain Crops—Actual and Projected Production

Non-Food-grain Crops	Production 1970-71	Production 1973-74	Peak targetted production 1978-79	Average removal of nutrients (kg/tonne of grain yield)			Removal of nutrients (million tonnes)											
							1970-71				1973-74				1978-79 (Target)			
				N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)
	(million tonnes) §																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
oil seeds .	9.3	8.7	12.5	30.7	13.0	27.1	0.29	0.12	0.25	0.66	0.27	0.11	0.24	0.62	0.38	0.16	0.34	0.88
sugarcane (Gur) .	13.0	14.0	17.0	16.6	6.0	33.0	0.22	0.08	0.43	0.73	0.23	0.08	0.46	0.77	0.28	0.10	0.56	0.94
cotton* .	4.5	5.8	8.0	44.2 (per bale)	34.0	142.0	0.20	0.15	0.64	0.99	0.26	0.20	0.82	1.28	0.35	0.27	1.14	1.76
.	4.9	6.2	7.7	18.0 (per bale)	18.0	27.0	0.09	0.09	0.13	0.31	0.11	0.11	0.17	0.39	0.14	0.14	0.21	0.49
potato .	4.8	4.6		5.0	1.8	8.0	0.02	0.009	0.04	0.069	0.02	0.008	0.04	0.068				
tobacco .	0.36	0.44		7.9	1.7	4.8	0.0028	0.0006	0.0017	0.0051	0.0035	0.0007	0.0021	0.0063				
tea .	0.42	0.47		22.0	8.0	27.0	0.0092	0.0034	0.0113	0.0239	0.0103	0.0038	0.0127	0.0268				
coffee .	0.11	0.09		45.3 (per tonne)	4.9	20.1	(amounts too small to be taken into consideration)				n.a.	n.a.	n.a.	n.a.				
							0.8320	0.4530	1.5030	2.7880	0.9038	0.5125	1.7448	3.1611	1.15	0.67	2.25	4.07
						Total	0.83	0.45	1.51	2.79	0.90	0.51	1.75	3.16	1.15	0.67	2.25	4.07

*Production of cotton and jute are in million bales and nutrients removal calculated per bale of production

APPENDIX 48.3

(Paragraphs 48.2.2 and 48.3.2)

Removal of Nutrients by Foodgrain and Non-Foodgrain Crops—Actual and Projected Production

(million tonnes)

Crops	1970-71				1973-74				1978-79				1980-81			
	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
foodgrain crops . .	3.33	1.24	5.02	9.59	3.12	1.18	4.88	9.18	4.24	1.71	6.33	12.28	4.17	1.64	6.69	12.50
non-foodgrain crops	0.83	0.45	1.51	2.79	0.90	0.51	1.75	3.16	1.15	0.67	2.25	4.07	1.52	0.90	3.20	5.62
total .	4.16	1.69	6.53	12.38	4·02	1.69	6.63	12.34	5.39	2.38	8.58	16.35	5.69	2.54	9·89	18.12

APPENDIX 48·4

Cropwise Fertiliser Requirement

(Paragraph 48.3.3)

Crop	Gross cropped area	Gross irrigated area	Gross area under high-yielding varieties 1973-74 target	Gross area under indigenous varieties irrigated	Gross area under indigenous varieties unirrigated	Fertiliser requirement N	P_2O_5	K_2O
			thousand ha				(million	tonnes)
Cereal crops								
paddy	35,983	13,861	10,100	3,761	22,122	0·59	0·30	0·08
wheat	14,854	6,457	7,700	..	7,154	0·20	0·14	0·07
barley	3,333	1,509	..	1,509	1,824	0·09	0·05	..
maize	5,614	669	1,200	..	4,414	0·17	0·08	0·08
jowar	17,902	707	3,200	..	14,702	0·29	0·29	..
bajra	12,196	382	2,800	..	9,996	0·20	..	..
ragi	2,417	390	..	390	2,027	0·26	0·05	0·01
other cereals	5,075	119	..	119	4,956	0·09	0·04	..
Pulses & other Important crops								
gram	7,997	1,249	..	1,249	6,748	0·12	0·24	..
other pulses	15,088	761	..	761	14,327	0·17	0·33	..
sugarcane	2,069	1,580	..	1,580	489	0·28	0·14	0·14
other food crops	6,429	1,792	..	1,792	4,637	0·10	0·50	..
oilseeds	15,080	753	..	753	14,327	0·30	0·30	..
cotton	7,715	1,285	..	1.285	6,430	0·45	0·22	0·19
jute and other fibres	1 403	..	..	..	1,403	0·04	0·28	0·04
tea	346	..	..	..	346			
coffee	152	..	..	..	152	0·05	0·03	0·03
					total	3·40	2·99	0·64

APPENDIX 48·5

(paragraph 48·3·13)

Fertiliser Requirement for Total Cropped Area based on Doses recommended following Fertiliser Trials

Crop	Gross area under crops (1970-71)*	Area under irrigation (1970-71)*	Gross area under high yielding varieties (1973-74 target)*	Gross area under indigenous varieties		Fertiliser requirement		
				Irrigated	Unirrigated	N	P_2O_5	K_2O
	thousand ha					(million tonnes)		
1	2	3	4	5	6	7	8	9
Food crops								
Paddy	37,387	14,917	10,100	4,817	22,470	2·41	1·38	1·38
wheat	18,139	9,829	7,700	2,129	8,310	1·34	0·71	0·71
barley	2,558	1,328	..	1,328	1,230	0·10	0·05	..
maize	5,836	925	1,200	..	4,911	0·36	0·19	0·19
jowar	16,994	626	3,200	..	16,368	1·17	0·59	0·10
bajra	13,192	514	2,800	..	12,678	0·93	0·46	0·08
ragi	2,525	334	..	334	2,191	0·09	0·06	..
other cereals	5,030	110	..	110	4,920	0·09	0·05	..
gram . . .	7,847	1,224	..	1,224	6,623	0·09	0·17	..
arhar	2,652	12	..	12	2,640	0·03	0·05	..
other pulses	12,499	772	..	772	11,727	0·13	0·25	..
sugarcane . . .	2,616	1,929	..	1,929	687	1·01	0·51	0·51
other foodcrops . .	5,608	1,926	..	1,926	3,682	0·09	0·45	..

APPENDIX 48.6—*concld.*

1	2	3	4	5	6	7	8	9
Non-Food crops								
oilseeds . . .	14,641	1,022	..	1,022	13,619	0·44	0·33	..
cotton . . .	7,886	1,287	..	1,287	6,599	0·27	0·14	0·14
jute & other fibres .	1,288	..	..	..	1,288	0·04	0·03	0·0
tea coffee . . .	352 167	.. ..	.. ..	.. ..	352 167	0·07	0·05	0·06
other non-foodcrops .	8,603	1,757	..	1,757	6,846	0·69	0·34	0·34
					total .	9·35	5·81	3·55

* 1974, Indian Agriculture in Brief 13th edition, DES.

(Paragraph 48·3·5)

APPENDIX 48·6

Estimated Fertiliser Requirement by 1978-79*

area : Mha
dose : kg/ha
nutrient requirement : million tonne

Crops	nutrients	Irrigated						Unirrigated						Total	
		HYVP			local varieties			HYVP			local varieties				
		area	dose	nutrient requirement	area	dose	nutrient requirement	area	dose	nutrient requirement	area	dose	nutrient requirement	area	nutrient requirement
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Foodgrains :															
paddy .	N	18·00	80	14·40	2·00	35	0·70				20·00	15	3·00	40·00	18·10
	P_2O_5	18·00	35	6·30	2·00	10	0·20				20·00	0	..	40·00	6·50
	K_2O	18·00	25	4·50	2·00	0	..				20·00	0	..	40·00	4·50
wheat .	N	12·00	80	9·60	..	..	..	1·50	40	0·60	8·50	15	1·28	22·00	11·48
	P_2O_5	12·00	35	4·20	..	..	..	1·50	20	0·30	8·50	0	..	22·00	4·50
	K_2O	12·00	25	3·00	..	..	..	1·50	10	0·15	8·50	0	..	22·00	3·15
maize .	N	1·00	70	0·70	1·00	30	0·30				4·50	15	0·68	6·50	1·68
	P_2O_5	1·00	30	0·30	1·00	10	0·10				4·50	0	..	6·50	0·40
	K_2O	1·00	20	0·20	1·00	0	..				4·50	0	..	6·50	0·20

APPENDIX 48.6 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
jowar	N	1·50	40	0·60				1·00	40	0·40	15·50	10	1·55	18·00	2·55
	P_2O_5	1·50	15	0·23				1·00	15	0·15	15·50	0	..	18·00	0·38
	K_2O	1·50	10	0·15				1·00	10	0·10	15·50	0	..	18·00	0·25
bajra	N	1·00	40	0·40				4·00	40	1·60	8·50	10	0·85	13·50	2·85
	P_2O_5	1·00	15	0·15				4·00	15	0·60	8·50	0	..	13·50	0·75
	K_2O	1·00	1·00	0·10				4·00	10	0·40	8·50	0	..	13·50	0·50
total for cereals	N	33·50		25·70			1·00			2·60			7·36		36·66
	P_2O_5	33·50		11·18			0·30			1·05			..		12·53
	K_2O	33·50		7·95			..			0·65			..		8·60
other cereals	N				3·00	10	0·30				6·00	0	..	9·00	0·30
	P_2O_5				3·00	0	..				6·00	0	..	9·00	..
	K_2O				3·00	0	..				6·00	0	..	9·00	..
pulses	N				3·00	10	0·30				21·00	5	1·05	24·00	1·35
	P_2O_5				3·00	20	0·60				21·00	10	2·10	24·00	2·70
	K_2O				3·00	0	..				21·00	0	..	24·00	..
total other cereals and pulses	N						0·60						1·05		1·65
	P_2O_5						0·60						2·10		2·70
	K_2O						..						..		..
total food-grains	N			25·70			1·60			2·60			8·41		38·31
	P_2O_5			11·18			0·90			1·05			2·10		15·23
	K_2O			7·95			..			0·65			..		8·60

non-foodgrains :											
oilseeds	N		2·00	20	0·40		13·17	10	1·32	15·17	1·72
	P_2O_5		2·00	25	0·50		13·17	15	1·98	15·17	2·48
	K_2O		2·00	10	0·20		13·17	0	..	15·17	0·20
sugarcane	N		2·56	100	2·56		0·64	50	0·32	3·20	2·88
	P_2O_5		2·56	40	1·02		0·64	20	0·13	3·20	1·15
	K_2O		2·56	15	0·38		0·64	0	..	3·20	0·38
cotton	N		2·30	60	1·38		6·30	30	1·89	8·60	3·27
	P_2O_5		2·30	25	0·57		6·30	0	..	8·60	0·57
	K_2O		2·30	10	0·23		6·30	0	..	8·60	0·23
jute	N		0·15	40	0·06		0·71	30	0·21	0·86	0·27
	P_2O_5		0·15	15	0·02		0·71	10	0·07	0·86	0·09
	K_2O		0·15	10	0·01		0·71	5	0·03	0·86	0·04
tobacco	N		0·10	50	0·05		0·40	20	0·08	0·50	0·13
	P_2O_5		0·10	30	0·03		0·40	10	0·04	0·50	0·07
	K_2O		0·10	30	0·03		0·40	10	0·04	0·50	0·07
other crops and plantation crops	N		4·85	60	2·91		10·55	25	2·64	15·40	5·55
	P_2O_5		4·85	25	1·21		10·55	10	1·06	15·40	2·27
	K_2O		4·85	10	0·48		10·55	10	1·06	15·40	1·54
total non-food-grain crops	N				7·36				6·46		13·82
	P_2O_5				3·35				3·28		6·63
	K_2O				1·33				1·13		2·46
total requirement.	N	25·70			8·96	2·60			14·87		52·13
	P_2O_5	11·18			4·25	1·05			5·38		21·86
	K_2O	7·95			1·33	0·65			1·13		11·06

* 1. Based on estimated area under crops and most likely doses of fertiliser application.

2. Approach Paper for Fifth Five Year Plan, Ministry of Agriculture and Irrigation (Fertiliser Division).

APPENDIX 48·7

(Paragraph 48·3·17)

Production Imports and Consumption of Chemical Fertilisers in India —1961-74*

(thousand tonnes)

Year	Nitrogenous (N) availability Produ-ction	Im-ports	Total	Con-sump-tion	Phosphatic (P_2O_5) availability Produ-ction	Im-ports	Total	Con-sump-tion	Potassic (K_2O) availability Im-ports	Total	Con-sump-tion	Total nutrients ($N+P_2O_5+K_2O$) availability Pro-duc-tion	Im-ports	Total	Con-sump-tion
1961-62 . .	145	142	287	250	66	..	66	61	32	32	28	211	174	385	339
1962-63 . .	178	252	430	333	80	10	90	83	40	40	36	258	302	560	452
1963-64 . .	222	226	448	377	107	12	119	116	64	64	51	329	302	631	544
1964-65 . .	240	233	473	555	131	12	143	149	57	57	69	371	302	673	773
1965-66 . .	233	326	559	575	111	14	125	132	85	85	77	344	425	769	784
1966-67 . .	308	632	940	738	145	148	293	249	118	118	114	453	898	1351	1,101
1967-68 . .	367	867	1,234	1,035	190	349	539	335	270	270	170	557	1,486	2,043	1,540
1968-69 . .	543	842	1,385	1,208	210	138	348	382	213	213	170	753	1,193	1,946	1,760
1969-70 . .	716	667	1,383	1,356	222	94	316	416	120	120	210	938	881	1,819	1,982
1970-71 . .	830	477	1,307	1,479	229	32	261	541	120	120	236	1,059	629	1,688	2,256
1971-72 . .	952	481	1,433	1,798	278	248	526	558	268	268	300	1,230	997	2,227	2,656
1972-73 . .	1,060	665	1,725	1,839	326	204	530	581	325	325	348	1,386	1,194	2,580	2,768
1973-74 (P) .	1,060	675	1,735	1,829	317	267	584	650	347	347	360	1,377	1,289	2,666	2,839

* data obtained from Ministry of Agriculture and Irrigation Government of India (Fertiliser Divison).

APPENDIX 48·8

(Paragraph 48·5·9)

Estimates of some of the Waste products Available in the Country Annually

Waste products	million tonnes
bagasse (sugarcane)	5·3
paddy (husk)	16
paddy (bran)	2
jute (drystick)	1·7
cake (groundnut, castor, sesamum, rape, mustard and linseed)	7
cake (cotton)	11.4
dung (dry)	290
cotton (soft waste)	215 million kg.
cotton (hard waste)	35 million kg.

(Paragraph 48·6·3)

APPENDIX 48·9

Pattern of Feedstock Utilisation for Nitrogen Capacity (installed and planned)

(thousand tonnes)

Plant/Project	Total nitrogen capacity	Capacity based on different feedstocks						Naptha requirement
		LSHS/ fuel oil	Natural gas	Coal/coke /lignite	Electricity	Imported ammonia	Naptha	
1	2	3	4	5	6	7	8	9
A. *Factories under Production* ;								
FCI—Sindri, Bihar	90	..	..	80	..	..	10	20
FCI—Nangal, Punjab	80	..	..	..	80	..	..	..
FCI—Namrup, Assam	45	..	45	..	..	..	..	..
FCI—Trombay, Maharashtra	81	..	..	..	..	..	81	90
FCI—Gorakhpur, U. P.	80	..	..	..	..	..	80	90
FCI—Durgapur, W. Bengal	152	..	..	..	..	..	152	160
HSL—Rourkela, Orissa	120	..	..	70	..	..	50	75
FACT—Alwaye, Kerala	82	..	..	..	4	..	78	90
FACT—Cochin, Kerala	152	..	..	..	..	..	152	160
NLC—Neyveli, Tamil Nadu	70	..	..	70	..	..	..	..
MFL—Manali, Tamil Nadu	164	..	..	..	..	..	164	220
HSL—Bhilai, M. P.	6·7	..	..	6·7 (by-product)	..	..	..	..

HSL—Durgapur, W. Bengal	4.4	..	..	4·4 (by product)	..	..	..	..
HSL—Rourkela, Orissa	5·8	..	..	5·8 (by product)	..	..	..	..
HSI—Bokaro, M. P.	1·4	..	..	1·4 (by product)	..	..	..	..
EID—Parry—Ennore	16	..	..	..	..	..	16	16
NCJM—Varanasi, U. P.	10	..	..	10	..	..	..	..
GSFC—Baroda, Gujarat	216 (218)	..	46	..	..	..	170	130
Coromandel Fort. Ltd., Vizag (A. P.)	80	..	..	..	..	..	80	85
SCI—Kota, Rajasthan	110	..	..	..	..	..	110	120
IEL—Panki, Kanpur, U. P.	200	..	..	..	..	..	200	225
Zuari Agro-Chemicals, Goa	170 (198)	..	..	..	..	..	170	220
ISCO—Jamshedpur, Bihar	4·8	..	..	4·8 (by product)	..	..	..	..
IISCO—Burnpur Kulti, W. Bengal	4·7	..	..	4·7 (by product)	..	..	..	..
Burrakur Coal Co. Ltd., Bansjora, Bihar	0·3	..	..	0·3 (by product)	..	..	..	..
Total (A)	1,946	..	91	258	84	..	1,513	1,701

APPENDIX 48.9 (contd.)

1	2	3	4	5	6	7	8	9
B. *Under Implementation :*								
FCI—Barauni	152	..	..	..	..	..	152	160
FCI—Namrup	152	..	152	..	..	..	..	..
FCI—Gorakhpur	51	..	..	..	..	..	51	55
FCI—Nangal (Exp.)	152	232	..	..	(—)80	..	..	..
FCI—Haldia	152	152	..	..	..	..	..	..
FCI—Talcher	228	..	..	228	..	..	..	..
FCI—Ramagundam	228	..	..	228	..	..	..	..
FACT—Cochin (II) (Exp.)	40	..	..	..	..	40	..	..
Mangalore Chem. & Fert. Ltd., Mangalore	160	..	..	..	..	..	160	160
SPIC—Tuticorin	258 (263)	..	..	..	..	..	258	258
SCI—Kota	42	..	..	..	..	..	42	42
IFFCO—Kandla	215	..	215	..	..	..	..	80
GSFC—Baroda	17	..	..	..	..	..	17	17
Coromandel Fert. Ltd., Vizag	9	..	..	..	..	..	9	9
Total (B)	1,856	384	367	456	(—)80	40	689	781

C. *Approved in principle :*								
FCI—Trombay	132 (75)	..	..	..	..	132	..	..
FCI—Sindri (Modernisation)	139 (129)	219	..	(—)80	..	..	..	..
FCI—Korba	228	..	..	228	..	..	..	..
TIDCO—Tuticorin	15 (10)	..	..	..	..	..	15	15
Tata Fert. Project, Mithapur	160	160	..	..	..	..	..	..
NCJM—Varanasi	27 (20)	..	..	(—)10	..	..	37	40
Maharashtra Coop. Fert. & Chemicals—Thana	60	..	..	..	..	..	60	80
Total (C)	761	379	..	138	..	132	112	135
D. *Under consideration :*								
FCI—Paradeep	342	—NOT KNOWN—						
Bhatinda Project, Bhatinda	228							
Mathura Project, Mathura	228							
Panipat Project, Panipat	228							
Shaw Wilace & Co. Ltd., Kakinada	228							

APPENDIX 48·9—(contd.)

1	2	3	4	5	6	7	8	9
SCI—Kota (New Plant)	342	—NOT KNOWN—						
GSFC—Baroda (New Plant)	228							
Zuari Agro-Chem. Ltd., Kamptee	228							
SPIC—Tuticorin (Exp.)	342							
Mangalore Chem. & Fert., Mangalore (Exp.)	228							
IEL—(Location not yet finalised)	228							
Andrewyule—Mirzapur	228							
IFFCC—Phulpur	228							
total (D)	3,306	..	..	..	..	..	..	..
total (A)+(B)+(C)	4,563	763	458	852	4	172	2,314	2,617
grand total (A)+(B)+(C)+(D)	7,869	763	458	4,158 (includes D)	4	172	2,314	2,617

ource : i) GOI, M/O Petroleum & Chemicals, Department of Chemicals.
ii) Bracketed figures are from Fertiliser Statistics 1972-73, Table 1.01
iii) Name of the projects with expected desired/production under (D) i.e. projects under consideration are also from Fertiliser Statistics 1972-73, Table 1.01.

ABBREVIATIONS EXPLAINED

FCI	Fertiliser Corporation of India Ltd.	SCI	Shriram Chemical Industries
HSL	Hindustan Steel Ltd.	IEL	Indian Explosives Ltd.
FACT	The Fertilizer and Chemicals Travancore Ltd.	TISCO	Tata Iron & Steel Co. Ltd.
NLC	The Neyveli Lignite Corporation Ltd.	IISCO	Indian Iron and Steel Co. Ltd.
MFL	Madras Fertilizers Ltd.	SPIC	Southern Petro-Chemical Industries Corporation Ltd.
NCJM	New Central Jute Mill Co. Ltd.	IFFCO	Indian Farmers' Fertiliser Cooperative Ltd.
GSFC	Gujarat State Fertilizers Co. Ltd.	TIDCO	Tamil Nadu Industrial Corporation.

APPENDIX 48·10

(Paragraph 48·6·16)

Equivalent Acidity and Basicity of Different Fertiliser Materials*

Type of fertiliser	Name of the material	Total nitrogen	Total P_2O_5	Equivalent acidity**	Equivalent basicity**
1	2	3	4	5	6
NITROGENOUS	Ammonia, anhydrous .	82·0	..	148	..
	Ammonim chloride .	24·0	..	128	..
	Ammonium nitrate .	33·5		60	..
	CAN (Calcium ammonium nitrate) . . .	20·5	..	0	0
	Ammonium sulphate .	20·5	..	110	..
	Ammonium sulphate nitrate	26·0	..	93	..
	Calcium cyanamide . .	21·0	..	..	..
	Sodium nitrate . .	16·0	..	..	20
	Calcium nitrate . .	15·5	..	..	21
	Urea	45·0	..	80	..
	Urea-formaldehyde .	38·0	..	68	..
PHOSPHATIC .	Basicslag . . .	..	4·8	..	basic
	Calcium metaphosphate .	..	64	0	0
	Dicalcium phosphate	..	37	..	25
	Superphosphate (Single) .	..	16	0	0
	Triple superphosphate .	..	42.0	0	0
POTASSIC .	Muriate of potash .	..	50.0	0	0
	Sulphate of potash	..	..	0	0
NITROGEN	Ammoniated supper .	2.0	14.0	0	0
PHOSPHORUS	phosphate (ordinary).	5·0	20·0		
COMPLEX	Ammoniated superphosphate double	4·0—6·0	40·0—49·0	11—14	..
	Ammonium nitrate dicalcium phosphate . .	20·0	20·0	25	..
	Diammonium phosphate .	21·0	53·0	77	..
	Diammonium phosphate ammonium sulphate .	20·0	20·0	93	..

13—3 Deptt. of Agri/76

APPENDIX 48.10 (contd.)

1	2	3	4	5	6
	Monoammonium phosphate ammonium sulphate .	16·0	20·0	86	..
	Urea-superphosphate .	7·0	data not available	13	..
NITROGEN POTASSIUM MATERIAL	Potassium nitrate . .	13·0	..	..	23
	Sodium Potassium nitrate	15·0	..	..	26
PHOSPHORUS-POTASSIUM MATERIAL	Monopotassium Phosphate	..	52·2	0	0
	Potassium metaphosphate	..	55·0	0	0
NITROGEN PHOSPHORUS POTASSIUM MATERIAL	Ammonium potassium phosphate	5·5	54·0	acidic	..

* Efficient use of Fertilisers, FAO, 1958, pp. 63-66.

** Equivalent acidity is the number of parts by weight of calcium carbonate required to neutralise the acidity resulting from the use of 100 parts of the fertiliser material. The 'equivalent basicity' is the number of parts by weight of calcium carbonate that corresponds to the acid neutralising power of 100 parts of the fertiliser material.

APPENDIX 48.11

(Paragraph 48·8.3)

Number of Soil Testing Laboratories in India and Their Capacity

State/Union Territory	Government Laboratories				Manufacturers and others				Total				Grand-Total	
	Stationary		Mobile		Stationary		Mobile		Government		Manufacturers and others			
	Number	Capacity × 1000	Number	Capacity × 1000	Number	Capacity × 1000	Number	Capacity × 1000	Number	Capacity × 1000	Number	Capacity × 1000	Number	Capacity × 1000
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Andhra Pradesh	22	160	2	18	4	15·6	..	..	24	178	4	15·6	28	193·6
Assam	3	50	..	..	1	30	1	30	3	50	2	60	5	110
Bihar	10	105	..	..	2	80	..	..	10	105	2	80	12	185
Gujarat	8	105	2	13	3	21·2	..	..	10	123	3	21·2	13	144·2
Haryana	16	255	..	..	..	..	..	..	16	255	..	..	16	255
Himachal Pradesh	5	35	..	..	..	..	..	..	5	35	..	..	5	35
Jammu & Kashmir	6	55	..	..	..	..	..	..	6	55	..	..	6	55
Kerala	16	108	..	..	1	30	..	..	16	108	1	30	17	138
Madhya Pradesh	7	27+NA	..	..	1	5	..	..	7	27	1	5	8	32
Maharashtra	5	48·5	..	..	9	53	..	..	5	48·5	9	53	14	101.5
Manipur	1	5	..	..	..	..	..	..	1	5	..	..	1	5
Karnataka	20	564	..	..	6	25	1	13	20	564	7	38	27	602
Orissa	5	70	..	..	1	0·5	..	..	5	70	1	0·5	6	70·5
Punjab	12	..	..	..	1	10	..	..	12	N.A.	1	10	13	10
Rajathans	4	90	1	10	1	3	..	..	5	100	1	3	6	103

APPENDIX 48.11 (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tamil Nadu	12	636	..	..	11	57·53	..	..	12	636	11	57·53	23	693·53
Tripura	1	10	..	..	..	..	..	..	1	10	..	..	1	10
Uttar Pradesh*	10	200	7	..	2	22	1	18·5	17	200	3	40·5	20	240·5
West Bengal	4	100	..	..	2	1·5	..	..	4	100	2	1·5	6	101·5
Nagaland	1	10	..	..	..	..	..	..	1	10	..	..	1	10
A. & Nicobar Islands	1	2·4	..	..	..	..	..	..	1	2·4	..	..	1	2·4
Delhi	2	1	..	..	..	..	..	..	2	1	..	..	2	1
Goa	1	10	..	..	1	N.A.	..	..	1	10	1	..	2	10
Pondicherry	2	28	..	..	..	..	..	..	2	28	..	..	2	28
TOTAL	174	2,674·9	12	46	46	354·33	3	61·5	186	2,720·9	49	415·83	235	3,136·73

*Additional 7 Laboratories

Source: Table No. 10.01, page I-277

N.A.=Not available.

Fertiliser Statistics

The Fertiliser Association of India, New Delhi, 1972-73.

49

PLANT PROTECTION CHEMICALS

1 INTRODUCTION

49.1.1 Insects, pathogens, weeds, rodents etc. throw a stiff challenge to man in the path of increasing agricultural production. They have developed special adaptations to life under varied environmental conditions. They become pests of man when their existence conflicts with his gains, comfort and welfare. The development of crop agriculture led to concentration of host plants, and literally "spread the table" for pests.

49.1.2 Before the advent of modern selective plant protection chemicals, pest attack was repelled by taking recourse to mechanical and cultural methods. At the early stages, some of the inorganic chemicals known to be toxic or poisonous were tried with success. But it was the insecticidal property of DDT, a chlorinated hydrocarbon, that revolutionised pest control, especially the insect pests. Through the path laid by the chlorinated hydrocarbons a wide variety of chemicals, e.g., organophosphorous and carbamates made their appearance in quick succession. A highly prospective industry has now been established, which has provided an effective arsenal for the control of pests, not only to enhance production but also to prevent wastage in stored condition. Because of the diversity of insects and diseases affecting the crops, the chemicals have as far as possible to be specific and selective in their action. We speak, therefore, of insecticides, fungicides, rodenticides, weedicides, nematicides, acaricides, molluscicides, etc. according to the nature of pests.

49.1.3 A crop is usually attacked by a number of pests which are often selective in the sense that they appear at different stages of growth of crop, but their virulence varies widely. The loss sustained by a crop depends on the extent and virulence of pest attack. If the attack is of an epidemic nature, the crop loss may be total in spite of all other inputs being optimal. Loss estimates reported by various state authorities vary under usual conditions from 8 to 45 per cent. The reporting is often based on so few observations that

its reliability may be doubted. This is particularly so because of the large number of factors, of which pests are one, that lead to loss of crops. Moreover, no uniform procedure for reporting is followed. These lacunae do not enable reliable estimates to be made of crop losses. The reports ordinarily mention the major pest but not the associated minor pests, diseases or weeds and are thus incomplete.

49.1.4 The efficiency of a chemical for plant protection is determined by the manner in which it is applied either as foliar spray or to the soil, the stage of growth of the pest and the crop, its physical form (solid powder or solution) and associated substances, e.g., solid or liquid medium. The technological potential of a chemical can be fully realised if the above conditions are optimal. A large number of exploratory experiments are, therefore, necessary before a chemical is included in a package of practice.

49.1.5 Chemicals are able to save a crop from pest attack only when applied in time. Sometimes, early apprehending of pest attack and prophylactic measures are sufficient to prevent crop loss. For this purpose systems of surveillance and warning have been built up for rice and wheat, which are the two major cereals. If done under expert supervision and in a systematic manner, any appreciable crop loss can be easily prevented. The chance of damage caused by possible epidemics can be definitely minimised. The network of the surveillance organisation should be as widespread as possible and cover important crop areas of the country with appropriate liaison between the States and the Centre. The training of personnel and methods to be followed should receive careful consideration.

49.1.6 The plant protection chemicals are generally costly, but because the amounts to be applied are usually small and the saving of crops is almost assured, the benefits accruing from the use of chemicals outweigh their costs. The benefit-cost ratios vary from 1.5 to 16 depending on the nature of the crop. In spite of the favourable benefit-cost ratios the farmers do not always faithfully follow the plant protection schedules, unless cash crops, large areas of high yielding varieties and high fertiliser application etc. are involved. This is mostly due to lack of education on the part of the farmers, who would not be inclined to use chemicals unless the damage is visible, when it is too late for plant protection measures.

49.1.7 Manufacture of pesticides for which knowhow is available has been increasingly adapted to country's needs. In order to match production with demand certain estimates of requirement of each of the currently employed pesticides have to be made. For this purpose three aspects are considered : (a) pest problems of major food,

cash, plantation and other crops; (b) choice of chemicals and dosage as per State Government's schedules; and (c) preference for indigenously produced pesticides. The gap between requirement and supply has to be filled up by increasing indigenous capacity. There is a genuine difficulty in assessing requirement of chemicals insofar as the science and technology of plant protection are dynamic. A greater difficulty arises from the fact that the recommended chemicals and their doses are not always those which are actually consumed. The prospects of indigenous production of pesticides seem to be bright Definite progress has been made in this direction and the strategy is fairly well laid. There would be need to import a few intermediates till their indigenous production is taken up.

49.1.8 Combined spraying of urea and pesticides has been tried with success. This procedure has been encouraged primarily to save application cost. But there are difficulties in making it a routine for all crops and pests. These difficulties may arise from the fact that fertilisers are more or less the same for all crops, whereas the pesticides are more specific. The compatibility of mixing is a more fundamental point for consideration. Systemic fungicides which are absorbed both by leaves and roots of plants stand a better chance of being mixed with fertilisers.

49.1.9 Toxicity of plant protection chemicals and their residual effects are problems to reckon with. Before release of these chemicals in the market, they are to satisfy tolerance limits fixed for such substances. Even then the hazards are likely, because of wrong use and negligent handling. Often, out of ignorance, farmers may be inclined to use pesticides indiscrimately in the hope of getting quick results. The users, particularly illinformed farmers, should have, therefore, the necessary knowledge about their toxic properties and the right way of handling them. Monitoring of pesticide residues in foods, milk, fats and soil, waters and tissues of men and animals by using, for the purpose of check, multiple analytical procedures and, if necessary, sophisticated equipment is called for. On the basis of this kind of analysis carried out over large areas and considerable period of time it may be necessary to alter old pesticide schedules. Pesticides may not always be so selective as to kill pests and leave useful organisms and enemies of pest in fact. The effect of pesticides on the latter should be one of the important criteria to make a choice out of alternative chemicals. The efficiency of pesticides can be increased and their toxicity hazards reduced to a great extent if pest control is carried out not by using chemicals alone but in combination with physical and bilogical methods as is done under the Integrated Pest Control.

49.1.10 The usefulness of pest control by means of chemicals depends among other things on the quality of the chemicals at the time of use. Rigorous checks are necessary by all possible means to prevent unscrupulous traders to sell substandard materials. There are various loopholes in regard to the sale and distribution of chemicals which might encourage unscrupulous traders to profit by malpractices. Strict control of quality at different levels of distribution and proper education of farmers appear to be the best answer. The Insecticides Act is yet to be watched as it is being implemented before its merits and demerits are realised.

49.1.11 The distribution of plant protection chemicals has been in the hands of State agroindustries departments, cooperatives, marketing federations and private agencies. Gradually, the state departments are withdrawing from distribution work leaving it to the cooperatives and private agencies who control more than 60 per cent of the business. Some complaints have been noted in regard to timely supply and availability. The State departments' responsibility in cases of scarcity cannot be overemphasised. Owing to lack of storage facilities at the village or the taluk level and difficulties of transport over long distances, timely supply is hampered. The farmers' service societies or custom service organisations can in such circumstances render useful help, not only in supplying but also in promoting the use of plant protection chemicals.

49.1.12 The important aspects mentioned above regarding plant protection chemicals in particular and of pest control in general have been discussed in this chapter in the context of the situation prevailing at present and keeping future prospects in view.

2 ROLE OF CHEMICALS IN PEST CONTROL FOR ENHANCED CROP PRODUCTION

49.2.1 Pesticide use in agriculture, in a technical sense, dates back to about the middle of the nineteenth century. If the development of crop protection is traced employing as milestones the prominent events in its history, these events are found to coincide closely with the occurrence of particular epiphytotics. The appearance in Europe of the powdery mildew of the vine (1845) was followed by an extension of the use of sulphur as a fungicide (1848); the severe outbreak, in France, of the downy mildew of the vine (1879) was followed by Millardet's discovery of the fungicidal value of the copper sulphate-lime mixture (1882). The spread of Colorado beetle (1850-59) was countered by the introduction of Paris Green (1867), an arsenical, later to be displaced by lead arsenate (1892), a material first used in the United States of America (USA) during

the Gipsy moth epidemic of 1889. The introduction of hydrocyanic acid and the "tent" method of fumigation (1886) followed the rapid spread, in California, of certain scale insects (1886).

49.2.2 Until 1939, most pesticides were inorganic chemicals, relatively simple in nature, plus a few insecticides of plant origin. A few organic chemicals were gradually introduced. But the discovery of the insecticidal nature of DDT in 1939 revolutionised the concept of pesticides and pest control, especially insect control. Since that date, many new pesticides have been discovered. At about the same period opened the field of organophosphorus insecticides which led to the development of parathion, tepp, coumaphos, demeton and many more. This period also saw the discovery of two weed killers, 2,4-dichloro phenoxyacetic acid (2,4-D) and 4-chloro-2-methylphenoxyacetic acid (MCPA), but they were not known publicly until the end of the World War II. The success so far achieved demonstrated the commercial possibilities of chemical weed control and stimulated extensive research work which has brought in a range of herbicides well beyond this group. Other pesticides like fungicides, nematicides and rodenticides have also been discovered. Discoveries of new synthetic pesticides have sparked off exciting advances and major breakthroughs in the control of pests. Chemicals have subdued pests that once caused widespread crop destruction and created national calamities.

49.2.3 The new cropping patterns and the luxuriant growth of plants, induced by the use of fertilisers and irrigation have created tremendous pest and disease problems. The control of pests enables a crop to yield its maximum within the limitations of its environment. The absence of such a control, the degree of damage inflicted on the crop determines the quantum of its yield, which may vary from poor harvest to none at all. Because chemicals have proved most effective against pests, they have received by far the greatest attention.

49.2.4. The use of recommended dosages of plant protection chemicals enhances crop production. Unlike fertilisers, pesticides do not increase yield but only control the losses. Fertilisers used in amounts less than the recommended doses yield less, but in the case of pesticides, a smaller dose than that recommended may not only yield less but also encourage resistant varieties of pests. Hence, plant protection schedules should be followed scrupulously to avert such a contingency.

49.2.5 Other chemicals which have been tried on a small scale to control insects are the chemosterilants, sex attractants and juvenile hormones. Chemosterilants sterilise insects and controls propagation. Applied to beetles, butterflies, bugs, flies and spider mites, these chemicals have shown promise, but their practical use awaits solution of

toxicological problems. Sex attractants are highly specific chemicals but too difficult and expensive to synthesise. They are efficacious only in very small dosages, but sex repellents at high concentrations. Juvenile hormones applied at the appropriate stage stop further growth of insects and thereby render them ineffective. Most of these chemicals are, however, very unstable and hence cannot be relied upon. Synthesis of more stable analogues is being attempted. Being biodegradable, toxicity problems do not arise with juvenile hormones. Even though costly, interest in these substances is growing because they seem to have the answer for pollution caused by the use of the common protection chemicals.

3 EXTENT OF CROP LOSS DUE TO INSECT PESTS AND DISEASES

49.3.1 That considerable loss in yield of crops occurs due to ravages of pests in the field is universally acknowledged. Serious crop failures have occurred in India due to the attack of insect pests and especially diseases. Epiphytotics due to Helminthosporium disease of rice were reported in 1918-19 from Krishna-Godavari delta and in 1942 from undivided Bengal, which led to acute shortage of rice. This was one of the contributing factors of the illfamed Bengal Famine. Severe occurrences of blast disease of rice in Tanjore (Thanjavur) delta were recorded in 1919 and later in other parts of India. Epiphytotics of red rot of sugarcane in Uttar Pradesh and Bihar (1937-42 and 1946-47), black rust of wheat in Madhya Pradesh and adjoining states (1947), and in Bihar (1957), yellowing disease of rice (rice tungro virus) in Eastern Uttar Pradesh, Bihar and parts of West Bengal (1969), brown rust of wheat in Punjab, Haryana and Western Uttar Pradesh (1972-73) and pyrilla on sugarcane in Uttar Pradesh, Bihar and Haryana (1973) are reported to have caused considerable loss to the economy of the country. Estimated loss caused by stem rust in India during 1947 is about Rs. 50 crores, and the annual loss by smuts of jowar amounts to Rs. 10 crores. More recently, the brown planthopper of rice has been reported to have caused considerable loss in Kerala (1974).

49.3.2 It appears that there has been hardly any consistent and systematic effort to work out losses of crops due to pest on scientific

lines on an all-India basis. In the absence of any reliable estimate, various 'guesses' based on individual and official impressions have been in vogue. One of the most commonly repeated official guesses is that losses to crops due to ravages of insect pests, diseases and weeds amount to about 20 per cent, the monetary value being over Rs. 1,000 crores every year, most likely in respect of food crops only. The guesses ventured by individual scientists based on limited information may be considered as 'felt loss', which for diseases and insect pests are shown respectively in Appendices 49.2 and 49.3. Appendix 49.4 gives information on felt loss and loss estimation due to nematodes. It will be seen that the guesses vary widely and hence no definite percentage loss can be fixed. Appendices 49.5 to 49.7, 49.8(I) and 49.8(II) give some loss estimations due to diseases, insect pests, nematodes, weeds and rats respectively based on small scale experiments. The latter have limited applicability and hardly represent the acutal situation in the field.

49.3.3 According to an estimate made by the National Council of Applied Economic Research (NCAER) based on experiments undertaken in seven States between 1950-51 and 1965-66, the maximum loss due to pests recorded (40.3 per cent) was on cotton. Other crops like paddy, jowar, sugarcane, potato recorded losses ranging from 8.8 to 12.1 per cent, the lowest being 2.8 per cent in wheat. These loss estimates were based merely on the difference in yields between treated and nontreated plots. Moreover, in some cases the number of experiments was very small.[1]

49.3.4 The estimates made by the Programme Evaluation Organisation (PEO), Planning Commission, Government of India, in connection with the High Yielding Varieties Programmes during *Kharif* of 1967 and 1968 and *Rabi* of 1967-68 and 1968-69 are summarised in Tables 49.1 and 49.2 respectively (details in Appendices 49.9 and 49.10). Yield data were collected from the sampled participant cultivators by interview method and hence have limitations even though analysed satistically.

49.3.5 The results on loss estimates made by the Institute of Agricultural Research Statistics (IARS), in collaboration with the Central Rice Research Institute, Cuttack and Tamil Nadu and Andhra Pradesh State Departments of Agriculture, are given in Table 49.3 (details in Appendix 49.11). It will be seen from these different estimates that the losses vary a great deal from crop to crop and State to State.

1. Pesticides in Indian Agriculture. 1967 NCAER.

TABLE 49·1

Cropwise All India Average Yield and Percentage Losses Due to Insect Pests and Diseases of High Yielding Varieties during Kharif, 1967[1] and 1968[2]

Crop	Average yield (q)		Percentage loss due to insect pests and diseases	
	1967 *per ha	1968 per ha	*1967	1968
paddy	24·33	39·9	17·80	19·28
maize	20·43	45·0	6·57	6·58
bajra	11·09	8·7	11·91	..
jowar	7·88	10·6	12·90	26·92

*Data converted from per acre to per hectare.

1. Evaluation Study of the High Yielding Varieties Programme. Report for the Kharif—1967. Programme Evaluation Organisation, Planning Commission, Government of India, August 1968. PEO Publication No. 62, pp. 222-224.

2. Report on Evaluation of the High Yielding Varieties Programme Kharif—1968. Programme Evaluation Organisation, Planning Commission, Government of India, June, 1969 ,PEO Publication No. 67, pp.206-209.

TABLE 49·2

Cropwise All India Average Yields and Percentage Losses due to Insect Pests and Diseases of High Yielding Varieties During Rabi, 1967-68[1] and 1968-69[2]

Crop	Average yield (q)		Percentage loss due to insect pests and diseases	
	1967-68 *per ha	1968-69 per ha	*1967-68	1968-69
paddy	42·16	44·36	6·77	20·73
wheat	26·55	24·64	3·36	3·58
jowar	21·91	16·21	11·26	41·84

* Data converted from per acre to per hectare.

1. Evaluation Study of the High Yielding Varieties Programme. Report for Rabi 1967-68—Wheat Paddy and Jowar, Programme Evaluation Organisation, Planning Commission, Govt. of India 1968. PEO Publication No. 65 pp. 91-92 and pp. 122-123.

2. Evaluation Study of the High Yielding Varieties Programme. Report for the Rabi 1968-69—Wheat Paddy, Jowar, Programme Evaluation Organisation, Planning Commission, Government of India, November 1969. PEO Publication No. 68, pp. 166-169.

TABLE 49·3

Average Percentage Loss in Yield of Paddy, due to Incidence of All Major Diseases and Insect Pests.[1]

District	Crop season and duration of variety	Percentage loss*	
		Estimate	S.E.
Cuttack	sarad LDV**	13·00	2·63
	dalua SDV**	7·13	6·32
	dalua MDV**	11·38	5·72
Thanjavur.	kuruvai SDV	4·39	1·03
	kuruvai MDV	3·25	0·33
	samba LDV	10·46	1·65
	thaladi LDV	3·96	4·15
West Godavari	kharif LDV	10·57	2·06
	rabi MDV	14·43	2·95

* Far district.

** Stand respectively for short (less than 100 days) medium (100-300) and long (over 130 days) duration varieties,

[1]. Singh, D. et al 1971. Estimates of incinence of diseases and consequent field losses in yield of paddy crop. Indian Phytopath, 24, 446-456.

49.3.6 In reply to our questionnaire (vide Appendix 49.1), only Andhra Pradesh and Karnataka have indicated data on field losses caused by insect pest and diseases, as given in Apppendix 49.12. Whereas Andhra Pradesh has worked out losscss assuming 20 per cent as loss in general for all the crops, Karnataka has based loss figures on general estimation for each crop and indicated them as percentage of yield per hectare. For different crops and seasons, the losses vary from 2 to 35 per cent.

Guidelines for the Future

49.3.7 Sound methods for the accurate estimation of losses are essential, so that long term research programmes aimed at preventing losses could be formulated and launched. An important information for recording crop loss data is the 'intensity' of attack by insect pests and diseases, which depends primarily on their number present. It is sometimes necessary and possible to estimate the 'critical' or 'threshold' or often called 'economic threshold' level of intensity of attack, beyond which it would be uneconomic to take any control measures.

49.3.8 In India, most of the estimations of crop losses due to pests have been made either by chemical protection and comparing yields with unprotected crop, or estimates of damage made with artificially induced attacks, and trying to work out a correlation equation between the yield of a crop and pest intensity. Some workers have used expressions such as 'mild', 'light', 'moderate', or 'heavy' to define pest intensity, but they are not obviously precise for the purpose of correlation. Numerical categories or scores of intensities have been attempted by some, but they should be tested for their adequacy and practicability for characterising specific situations. Moreover, these studies do not give any indication of the more important criterion, namely the 'economic threshold'. It must not be assumed that a certain level of intensity of a pest and of the resulting damage would always cause the same yield loss, or that smaller and greater intensities would necessarily cause proportionate lower and higher crop losses. Environmental, varietal and many other local factors may profoundly affect such relationships. The need for a study of these factors in different localities and under different conditions cannot be overemphasised. The intensity of pest attack is no doubt the most important factor, but not the only one, in determining crop loss. For every crop a critical stage of pest of disease injury can be estblished, where an intensity-loss relationship is more valid than at any other stage. Most of the crops are, for instance, able to recoup from injuries by pest attack incurred early in their growth or away from the critical stage. Such a critical stage for each variety of crop should, therefore, be ascertained by careful experimentation.

49.3.9 The IARS should examine the available data on various coordinated trials carried out all over India to arrive at an estimate of crop losses by insect pests and diseases. The Institute may design experiments to enable valid estimates to be made of crop losses by insect pests and diseases.

49.3.10 Another point in this connection should be emphasised. Some of the chemicals and/or their solvents and carriers may affect yield responses independent of the chemicals. Their effects, if any, on crop response have to be taken into consideration. So far losses have been expressed either in percentage or in quantity or in monetary value. Crop loss estimates should preferably be expressed on a uniform basis.

49.3.11 The nature of research work and field study, the methodology to be followed and the organisation necessary to estimate crop loss are indicated below:

(i) Research work and field study : Epidemological studies on various pests, ecological studies on population dynamics, determination of economic threshold, off-season biology,

host-parasite relationship, critical growth stages of various crops etc. are some of the items of research work. For the purpose of verification, these studies have to be continued at least for 3-5 years under different agroclimatic regions and pest situations. Wherever possible, laboratory work and field testing may run simultaneously to gain time.

(ii) Methods : The methods to be followed in crop loss estimation have to evolve from research and field study, as stated above, together with a review of methodology practised elsewhere. The Food and Agricultural Organisation (FAO) of the United Nations Manual (1971) on Crop Loss Assessment Methods is going to be of great value. Neither pest populations nor crop losses are static but they change from year to year in a given location. Experiments should be conducted for at least three years at each of a number of locations. Such information needs to be updated, perhaps every 5 years. The need would be greater in future because of rapidly changing cultural practices, and introduction of new plant varieties and agricultural chemicals. Future work should pay attention to the determination of pest combinations in different regions.

(iii) Agencies : Keeping in view the pest problems of various crops in different regions and situations, the Indian Council of Agricultural Research (ICAR) may, without allowing duplication of work, sponsor problem-oriented well defined research projects in research institutions and agricultural universities. A close liaison with State Departments of Agriculture would be highly desirable. It may be opportune to have the cooperation of the pesticides industry at a consultative level.

Serious and Moderate Insect Pest and Diseases

49.3.12 A review of literature[1] and an analysis of the replies received from the States to the questionnaire (Appendix 49.1) issued by us reveal that a particular crop is generally attacked by a group of insect pests and diseases, some of which are serious and some moderate. Information on this aspect is scattered and a compilation seems worthwhile. Accordingly, tabular statements have been prepared for each crop as it is affected by various insect pests and diseases in different states. The tabular statements are given in

Plant Protection Bulletin, 1973. Pest and Disease Number. Plant Protection Adviser to the Government of India, Faridabad.

Appendices 49.13 to 49.23. In order to save space certain abbreviations have been used in respect of insect pests and diseases as shown in Appendix 49.24. In order to distinguish insect pests and diseases reported serious they are underlined, whereas the moderate ones are not. It would be noted that insect pests and diseases reported by the States are fewer and almost all of them are considered serious. In fact, moderate insect pests and diseases are usually ignored for the purpose of reporting. Literature information on insect pests and diseases is more extensive and lists a much greater number of them than are reported by the States. The purpose of listing moderate insect pests and diseases is to draw attention to those which are potentially serious, and have to be reckoned with in future. Table 49.4 gives in a nutshell the serious insect pests and diseases of some of the impotrant crops.

TABLE 49·4

Serious Insect Pests and Diseases of Some of the Important Crops.

Crops	Insect	Diseases
paddy . . .	gundhy bugs, green leafhoppers, white leafhoppers, swarming caterpillar, caseworm, gallmidge, hispa, grasshoppers, stemborer, mealy bug, army worms, ear cutting caterpillar.	blast, stem rot, root rot' bacterial leaf bligh, Foot rot, helminthosporium.
jowar, maize, bajra and lesser millets.	stem borer, earhead webbing caterpillar, black hairy caterpillar, red hairy caterpillar, midge, deccan wingless grasshopper, grasshopper (Maize), hairy caterpillers (jowar).	grain smut, loose smut' downy mildew (jowar), smut (millet), downy mildew (maize), grain-earhead disease (bajra)'
wheat, barley and oats	cutworms (wheat), bluebeetle (wheat), termites, earcockle.	yellow rust, covered smut (barley, oats), black rust, stripe disease (barley).
cotton . .	white fly, pink bollworm, spotted bollworms, stempborer, jassids, semiloopers, aphids, field cricket, grey weevil, gram weevil, leaf-roller.	wilt, black arm, anthrac_nose, grey mildew.
jute . . .	smilooper,' mealy bugs, stem weevil, cricket, mites.	foot rot.
sugarcane . .	pyrilla, topborer, stem borers	red rot, smut.

4 EFFICIENCY OF CHEMICALS IN PEST CONTROL AND INCREASING CROP PRODUCTION

49.4.1 Experiments on the efficiency of chemicals in controlling pests of crops have been conducted in the country by individual workers and under coordinated projects. Yield increase by the use of chemicals has in general been taken as a measure of their efficiency in controlling pests. Increases in yield due to control of insect pests with insecticides and control of weeds by using weedicides have been reviewed.[1,2] Results of the Maximum Protection Trial against insect pests on rice, a coordinated trial conducted by the All-India Coordinated Rice Improvement Project have shown the varying yield increases of the same variety of paddy in different locations and of different varieties at the same location. A similar compilation of data on the effect of fungicides on yield is not readily available. Some information collected from scattered publications is given in Appendices 49.25 and 49.26.

49.4.2 The data given in the above appendices show that chemicals not only control pests, but also increase the crop yields in varying degrees. The data further show the differences amongst the chemicals in their efficiency, dosage and time and number of applications. Experiments designed to find out the difference between the maximum chemical control of insects, and the effect that an insect resistant variety may have on ultimate yield, demonstrate that low insect infestations enable greater yields than those from the resistant selections. Insect resistance, however, is important at centres experiencing heavier insect attack, where resistant varieties give greater yields than susceptible varieties under treated conditions, however, in the presence of relatively severe insect attack, insect resistance possessed by a variety allows greater yields to be obtained, exceeding the high yielding susceptible varieties. The increase in yield because of protection is an indirect indication of susceptibility. It is under low infestations that the instrinsic differences in yield potential are exhibited. Since with the change in agricultural pattern more and more of high yielding varieties are likely to come under cultivation, it is necessary to have a continuous surveillance on various insect pests and diseases, so as to identify the particular regions where such pests are becoming important. Future studies on assessment of the

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1. 1971. Pradhan S. In tropics protection research is more needed than production research. *Ind. J. Entomol.* : *336*; 233-259.
2. 1968. Mani, V. S., K.C. Gautam and T. K. Chakraborty. Losses in crop yield in India due to weed growth. *PANS (C)*: 14: p. 142-158.

efficiency of chemicals in controlling pests to increase yield should preferably be undertaken with high yielding varieties at such regions.

49.4.3 Individual studies, assuming that they have been made under the same fertility conditions are generally concerned with a particular insect pest or a disease or a weed by using particular chemical or chemicals. There is often no clear mention of the presence of any other coexisting insect pest or disease or weed. All incidences have, however, to be recorded. In order to obtain maximum efficiency in controlling insect pests and diseases, it is necessary to find out the feasibility of using an insecticide, a fungicide and a weedicide at the same time, depending on the pest situation of the region.

49.4.4 The dosages of chemicals, number of applications and time of application are important factors in determining the efficiency of chemicals. In some but not all studies are these mentioned. Successful control is based only upon the correct identification of the pests, accurate knowledge of the life history and habits of the organism concerned, and host-parasite interaction. Also important are the critical stages of the host plants and pest intensity for regulating the use of the chemical and obtaining the maximum efficiency.

49.4.5 The main purpose of plant protection chemicals has been to control pests, thereby reducing the losses caused by them. Unlike fertilisers, these chemicals are ordinarily not known to have any direct effect on yield increase. But some studies have shown yield increases on controlling pests, which have not been directly correlated with the losses in yield caused by pests. Some of the chemicals used may have growth promoting power. It is practically impossible to have a total control of pests. Hence, all future studies should preferably be correlated with the losses caused by various pests under different conditions and in different regions. This would be possible when a good estimate of losses could be made.

Pest Resistant Varieties and Pesticide Use

49.4.6 A review of plant breeding work relating to the development of pest resistant varieties shows that efforts in this direction are quite extensive and cover a wide variety of crops and pests and diseases. It is often possible to evolve a variety fully resistant to a particular pest or disease, but ordinarily one obtains varieties having varying degrees of tolerance. On the degree of tolerance would depend the quantity of a pesticide to be used for plant protection, and to that extent the impact of tolerant varieties on pesticide consumption would be felt. The work of evolving resistant crop varieties is time consuming, and till then the use of pesticides has to be accepted. The greater the tolerance of varieties against pests, the greater

would be the reduction in pesticide requirement. Moreover, low pesticide consumption would mean reduction in pollution risk. It should be noted that along with the development of resistant/tolerant varieties of crops the insects and pathogens evolve more virulent strains, making the search for resistant/tolerant varieties a continuing one. It is the usual practice to change the same pesticide every two to five years, so that pesticide resistant varieties do not develop. Such quick changes may not be practiciable because of several factors. Among them are education of farmers, availability of new pesticides and their ready acceptability, conservatism on the part of farmers to discontinue use of those pesticides that have so long served them well.

Potentiality of Chemicals

49.4.7 With developing technology, various plant protection chemicals, nonsystemic (direct or protective) and systemic having more or less specific uses, have appeared in the market. These chemicals belonging to a wide variety of groups are of varying compositions. The main requirements for the satisfactory application of a chemical, used either for spraying or dusting, are : (a) high field performance determined by inherent toxicity, availability of the active constituent, coverage, initial retention of spray dust, and tenacity of the residue, (b) low phytotoxicity; (c) stability of the concentrate in storage; (d) stability after dilution to spray strength, sufficient to ensure the application of a uniform known concentration of active constituents; and (e) low toxicity to human beings, livestock, poultry and fish. Inherent toxicity and availability of active constituent in item (a) and item (b) refer to the characteristic properties of the particular insecticide or fungicide employed. Supplementary spray materials are used as 'activators' to improve effectiveness or as 'correctives' to reduce phytotoxic properties. Also are added spreaders to improve coverage, stickers to increase retention, and emulsifiers and protective colloids to enhance stability. The combination and compatibility of all the additives with the active constituent determine the potentiality of a chemical for pest control.

49.4.8 It has been known that chemicals belonging to various chemical groups vary in their efficacy in controlling pests. Similarly, chemicals within a particular group may vary in their efficacy. There is no single chemical which can control all insect pests, or fungi or weeds. Each chemical has its inherent specificity. Therefore, in the package of practices for crops, as far as plant protection is concerned, a few chemicals are recommended depending upon the insect pest and disease situation of the region. Weed control is usually recom-

mended separately. How chemicals combine to attack a motley of insect pests and diseases and reduce crop damage is not fully understood.

Application Methods

49.4.9 The conventional method of applying dilute solution/suspension of pesticides by means of spray nozzle at high rate is now regarded as both wasteful and time consuming The need is for development of compounds and methods with an eye to economise on materials and number of applications. The present trend in crop spraying is to apply more concentrated pesticides by means of low-volume sprayers. This has been made possible through the development of better formulations and special nozzles. Another technique is to use Low Volume Concentrate (LVC) pesticides which are applied in undiluted form a Ultra Low Volume (ULV) sprays. Such chemicals suit aerial spraying, but with the help of special nozzles they are suitable for ULV application using motorised ground equipment.

49.4.10 Of late, interest has been shown in the manufacture of granular formulations. With the development of systemic insecticides, fungicides and herbicides, granular formulations have a great scope and promise rapid increase of coverage, because of the efficacy and ease of application and accurate control of rate and placement. Moreover, they are safer to applicators and other desirable forms of life.

5. CHEMICALS IN FARMING SYSTEM-SURVEILLANCE AND WARNING

49.5.1 Following the adoption of various high yielding varieties of crops and new cropping patterns, a wide range of pest problems have shown up. Moreover, because of the introduction of new host crops, pests of minor importance may assume serious proportions. Insect pests and diseases of crops do not, as a rule, reach epidemic proportions suddenly. A systematic and periodical inspection of crops would provide a check before they do so. A timely warning to the cultivators, while the pests are in easily controllable stages, would enable them to reduce damage with less expenditure. For control of pests, the farmer is confronted with a multiplicity of chemicals to choose from. There is no single broad spectrum pesticide known which kills all pests. Moreover, prophylactic measures are more common in cash crops than food crops. Hence, with changing

cropping patterns, pest surveillance should become an integral part of crop production. In fact, surveillance of pests is recognised as an essential element in developing countries for maximising agricultural production. New introductions which are likely to bring hitherto unknown pests should be watched cautiously.

Surveillance in the Indian Scene

49.5.2 The first unified attempt of Pest Surveillance in India is the Wheat Diseases Surveillance which has been in progress since 1966-67, especially for the three important rust diseases of the crop. This was organised by the Indian Agricultural Research Institute (IARI), New Delhi, with the assistance of the Rockefeller and Ford Foundations. In 1974 after the withdrawal of assistance from both the Foundations the programme is being continued in collaboration with the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S). Following this, the Plant Pests and Diseases Surveillance Service was organised in 1969-70 by the Ministry of Agriculture and Irrigation, also with the assistance of the Ford Foundation. The *ad hoc* Rice Survey, Surveillance of Pests and Diseases of Rice was similarly organised by the DPPQ&S with the cooperation of the respective State departments and assistance of the Ford Foundation, during the kharif seasons of 1970, 1971 and 1972. With the subsequent withdrawal of the Ford Foundation, the DPPQ&S has carried out this programme during the kharif seasons of 1973 and 1974 with the assistance of the respective State departments. Since the methodology, set up, procedures etc. of the Plant Pests and Diseases Surveillance Service are entirely different from the other two surveillance programmes, they are discussed separately.

49.5.3 The primary thrust of the Wheat Diseases Surveillance was directed towards three rust diseases and their effect on newly introduced high yielding varieties, whereas that of the *ad hoc* Rice Survey was directed towards monitoring the population of *Nephotettix virescens* (Distant) (formerly *Nephotettix impicticeps* Ishihara), the vector of tungro virus, and recording its occurrence in relation to the vector population.

General Plan

49.5.4 The large size of the area to be covered by Wheat Diseases Surveillance and *ad hoc* Rice Survey Programmes dictated that survey methods employed are simple and fast, so that the maximum area could be covered in a minimum of time. Specific methods for estimating the incidence and reaction of diseases and insect pests were

devised for both the programmes. The counting of insect pests and diseases or of affected plants was time consuming and hence not done. All data collected were obtained by visual estimates only. Field reporting forms in both the cases were so made as to allow rapid noting of field data, and collecting comparable information from all areas. The training of both the Wheat Diseases and Rice Surveillance workers was imparted at the survey headquarters and at local headquarters respectively. It included identification of insects and diseases, methods of survey for estimating incidence of diseases and their relationships, and population of insect pests right in the field.

Main Findings

49.5.5 Wheat Diseases Surveillance[1] has provided very useful information on several points. The more important ones are: (a) a clear idea of the approximate date of appearance of rusts in different parts of the country; (b) South India as the primary source of black rust inoculum; northern hills contribute, if at all, very little to this epidemic, but has brought to the forefront the greater menace of brown rust; and (c) a more precise idea about the overall performance of high yielding dwarf wheat varieties than could be otherwise obtained. All this information may be used to build up a disease forecasting system, as is being done in respect of black rust movement.

49.5.6 The information gathered during the three survey seasons in respect of the *ad hoc* rice survey[2,3] enables some general statements to be made as follows:

(i) virus symptoms were observed only when the affected area contained two or more adult vectors per hill;

(ii) no spread of the virus was observed unless the vector population was four or more adult leafhoppers per hill;

(iii) newly introduced varieties appeared to allow earlier and heavier populations of the leafhopper vector;

(iv) high populations of the vector in areas not previously affected with the virus did not show virus symptoms, whereas areas with a past history of virus outbreaks showed the virus when the vector reached two adults per plant;

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1. Dr. L. M. Joshi, IARI, New Delhi. Personal Communication.

2. Lowe, John A. and P. Nandi, 1972 Surveillance of Pests and Diseases of Rice in India, with Special Reference to the Occurence of Tungro Virus. The Ford Foundation, New Delhi, India.

3. Lowe John A. 1972. Rice Survey of 1972. The Ford Foundation, New Delhi, India.

(v) heavy daily rainfall (50 mm and above) and high temperature (33°C and above) may be major deterrents for the build up of vector population; and

(vi) Light constant rainfall with optimum temperature allows rapid build-up of the population and potential outbreak of tungro virus.

49.5.7 The information gathered by the Wheat Diseases Surveillance and the *ad hoc* Rice Survey during the past years has been of great value, taking into consideration the well defined objectives of these programmes. Additionally, the Wheat Diseases Surveillance Work has made it possible to give some indication of the probable occurrence of black rust of Wheat. It has, in fact, contributed directly to the need of the breeders and kept the latter and the pathologists ahead of the fungus. The Rice Survey has similarly given some indication of the possible occurrence of tungro virus, for which timely insecticidal treatment may be resorted to for counteracting rise in vector population early in the crop season. Rice Survey work has further shown that newly introduced dwarf varieties appear to allow earlier and heavier population of the leafhopper vector. Moreover, an 'off-season' survey has indicated the survival of tungro virus and the existence of other strains of the virus. The Wheat and Rice Surveillance Programmes have clearly demonstrated that information can be gathered from numerous farmers' fields in the wheat and rice growing tracts. The experience suggests that for the success of such programmes freedom to travel and transport facilities for collecting information from the field should be ensured. There is a need to have the surveillance programme continued throughout the year beyond the wheat growing season, particularly in the hills, for getting a clear understanding of the inoculum potential, perpectuation survival and movement of rust spores.

49.5.8 The *ad hoc* Rice Survey should be placed on a permanent footing to allow it to carry on 'off-season' surveys preferably in the endemic areas. Some information on the survival of tungro virus has been obtained through only one survey. Moreover, it has not been established yet how the leafhopper continues its existence in the next season, when in most cases, there is only one crop and the summer temperature is high. Other problems of insect pests and diseases could be similarly tackled by means of direct approach.

Plant Pests and Diseases Surveillance Service

49.5.9 An insect pest and disease surveillance project got started from January, 1970 by the Government of India with the help of

four State Governments, the Ford Foundation and the India Meteorological Department. It was initially for a period of two years and the work was to start at four districts under the innovative Intensive Agriculture District Programme (IADP), viz, Raipur (Madhya Pradesh), Sambalpur (Orissa), Thanjavur (Tamil Nadu) and West Godavari (Andhra Pradesh). Subsequently, the Government of India gave its sanction to a National Plant Pests and Diseases Surveillance Service to be operated during the Fourth Plan. The project intended to establish 'reporting centres' in selected districts of various States apart from the four IADPs and to cover in course of time the remaining twelve IADP districts of Ludhiana (Punjab), Aligarh (Uttar Pradesh), Jammu/Anantnag (Jammu & Kashmir), Shahabad (Bihar), Alleppy or Palghat (Kerala), Mandya (Karnataka), Karnal (Haryana), Burdwan (West Bengal), Surat/Bulsar (Gujarat), Kachar (Assam), Bhandara (Maharashtra) and Pali (Rajasthan). The working set up together with procedures and techniques was the same as those in the earlier IADP districts and organised in collaboration with the respective State departments.

49.5.10 The objectives of the Pests and Diseases Surveillance Service are: (a) to assess the methods used for surveillance of insect pests and diseases, and if possible, to develop better survey methods; (b) to gain knowledge about the distribution of insect pests and diseases and the levels of injury inflicted upon the host plants with a view to getting the control operation initiated as soon as it crosses the economic threshold of damage; (c) to establish a coordinated system of detection and surveillance of the major crop pests in the country which would assist in timely and effective mobilisation of plant protection facilities for pest control; and (d) evaluate the feasibility of the system of surveillance within the structure of the State agricultural organisation.

49.5.11 Central Pests and Diseases Surveillance Stations have been set up under the Directorate of PPQ&S in 12 districts, namely, Lucknow and Deoria (Uttar Pradesh), Malda (West Bengal), Bilaspur and Indore (Madhya Pradesh), Samastipur (Bihar), Cuttack (Orissa), Nizamabad and Elluru (Andhra Pradesh), Shimoga (Karnataka), Jullundur (Punjab) and Tiruchirapally (Tamil Nadu). In the case of these Central Stations, there would be a set up of 72 observation posts throughout the districts, 12 such in each of the 6 selected blocks of the district. Each of the 6 field reporters under a Surveillance Officer would be in charge of a block comprising the twelve observation posts. Paddy, wheat, sugarcane and potato are the crops on which information is collected. In the Fifth Plan, seven additional stations covering hitherto uncovored States have been proposed on a similar set up to that in the Fourth Plan.

49.5.12 In the Fifth Plan or the sake of establishing liaison between the surveillance information gathered and initiation of control actions at the Centre and State levels a post of Deputy Director (Surveillance) has been proposed. He would coordinate the entire work of pest intelligence collection and actions required thereof on an all-India basis, attend to problems requiring attention at Government level and provide policy direction for work. He would further arrange, in collaboration with the Central and State Government channels, for the dissemination of plant pests and diseases information down to the farming community and appropriate control measures.

Methods and Training

49.5.13 At present the methods given in Plant Pests Diseases Survey Manual for Plant Protection Workers' published by the DPPQ&S forms the basis of training, as it has been so during the training of the first group of field workers at the Central Plant Protection Training Institute, Hyderabad. With the experience gained during large scale adoption of methods given in the Manual, need has been felt for a thorough re-examination of the techniques and procedures of sampling stated in the Manual for the purpose of improving on them.

49.5.14 For various reasons, in none of the IADP districts the programme came up to expectations. Some of the reasons appear to be lack of proper appreciation of the objective of the programme; lack of staff exclusively for the programme, and adequate outside support; temporary nature of the programme, etc. However, the programme is being well implemented by the Central Stations and efforts are being made to improve on the working in the IADP districts. While some information exists on the correlation between pest build-up and agroclimatic conditions, a much more systematic study would be required to ensure accuracy of the forecast put out by surveillance stations. To get the best out of the surveillance system it would be necessary to build up effective warning procedure and for this it would be necessary to determine the economic threshold of the major pests. The agricultural universities and central research institutes are being associated in this task. Occurrence of insect pests and diseases and the distribution of species, exact times of occurrence, varieties of crops affected, plant growth stage preferred etc. would have to be studied in detail. Each individual insect pest and disease requires specific coverage to ensure correct interpretation of field information. It is considered necessary for the purpose of forecasting insect pest and disease occurrence to collect all possible information on the most

important insect pests and diseases of a particular crop of the area, leaving out of consideration those of minor importance. The latter should not, however, be ignored, because they may deserve attention in course of time.

49.5.15 Too little is known about many of the insect pests and diseases to provide the basis for developing sound techniques for sampling. Available techniques employed are often extremely difficult, mostly untried, and time consuming. Any surveillance project should continually strive to find methods suitable for determining the occurrence of each individual insect pest and disease. This activity should either be a part of the research work being done, or the subject of new research projects.

49.5.16 It is commonly believed that forecasting is possible without much background information. This idea is mistaken and should be corrected, otherwise it would act detrimentally to the surveillance programme. Most of the activities connected with surveillance are not indeed directly related to forecasting and even though the data collected in course of surveillance are not enough to issue warning to farmers, they are no doubt sufficient to indicate the magnitude of the problem.

49.5.17 The bases for forecasting are derived from observations on insect pest and disease incidence and its correlation with weather. The longer and the more consistent these observations are, the stronger is the foundation of forecasting. A vast amount of information on plant insect pests is available from light trap countings. If not referred to specific weather conditions, these data are rendered useless for the purpose of forecasting. New methods with well defined objectives, therefore, need to be evolved. If the problems to be investigated are not isolated and approached by means of specific methods, the information coming from the survey would continue to be of little value for the purpose for which it is designed.

Quarantine Operations

49.5.18 Movement of plant and plant materials may inadvertently introduce new plant diseases. Several such instances are known. For example, the bunchy top disease of banana caused by a virus which is transmitted by an insect introduced from Ceylon, wart disease of potato in Darjeeling introduced from Holland, golden nematode of potato in the Nilgiris spreading around Ootacamund, San Jose scale and woolly aphid of apple. The chances of such introductions have increased in view of the high speed of communication and the desire to bring in improved varieties of seeds to quicken agricultural production. In order to prevent disastrous consequences

of inadvertent introductions through such carriers as nursery stock, plants, cuttings, bulbs, tubers, roots, seeds, fruits, vegetables, nuts and leaves. Strict quarantine measures are enforced by international agreement. The Government of India took legislative measures as early as 1914 and set up plant quarantine stations at several seaports and land borders. With increase in air traffic quarantine measures have been enforced at all major airporsts. The quarantine stations are authorised not only to inspect and treat consignments with chemicals and fumigants but also to refuse entry and even destroy them in case found carrying pests and diseases. They carry out special inspections for certain consignments from countries known to be the home of particular pests and diseases. The responsibilities of the quarantine authorities who are required to keep strict vigil are very great, and as such the officers should be given all possible facilities and encouragement to carry out their obligations.

6 ECONOMICS OF THE USE OF AGRICULTURAL CHEMICALS

49.6.1 For an estimate of the economics of pesticide use, it is required to know the cost of chemicals and the yield increase due to pesticides. It is not easy to rigorously separate the yield components and assign each to the various inputs. Even if there is no visible sign of pest attack plant protection chemicals are known to increase yield, and when there is an attack of pests the loss may be 100 per cent even though other inputs are optimum, so that use of pesticides may give rise to 100 per cent yield increase. Under average conditions the yield increase due to pesticides may vary from 10 to 40 per cent. If the price of that much of produce is more than the cost of chemicals one can safely say that the treatment is economic. The commonly used pesticide schedule is so variable even for a single crop that the calculation of economics is difficult. If done approximately the values arrived at may be misleading.

49.6.2 Appendix 49.27 prepared for rice crop on the basis of information received from the different States, shows the variations in dosage and the nature of chemicals used. For instance, it is seen that benzene hexachloride (BHC) 10% dust, endrin 20% EC*, parathion 50% EC and phosphamidon 100% EC are more commonly used in most of the States in comparison to other insecticides, and their dosages, vary from State to State. A dosage of BHC 10% dust again varies from 10 kg/ha (Maharashtra) to 26 kg/hectare (Jammu

* Emulsifiable concentrates of Appendix 49.35.

& Kashmir), BHC 50% WP (wettable powder) from as low as 40 gm/ha (Manipur) to 5 kg/ha (Andhra Pradesh), and dichlorodiphenyl-trichloroethane (DDT) 50% WP from 1.25 kg/ha (Rajasthan) to 5 kg/ha (Andhra Pradesh and West Bengal). Regarding other pesticides, the dosage of endrin 20% EC varies from 930 ml/ha (Andhra Pradesh) to about as high as 3000 ml/ha (Karnataka); parathion 50% EC from 340 ml/ha (Uttar Pradesh) to about 1200 ml/ha (Karnataka) and phosphamidon 100% EC from 150 ml/ha (Jammu & Kashmir) to 1250 ml/ha (Karnataka). Similar variations with other insecticides have been observed. Besides insecticides, other pesticides have been recommended for the same crop with varying dosages, depending upon the pest problem. The recommended chemicals and dosages for crops other than rice have similar variations from State to State. In view of these variations and the arbitrary price fluctuations in different States and at different times the cost calculations lose much of their significance. In spite of these difficulties and uncertainties some attempts have been made to evaluate the benefit-cost ratios of pesticides treatments.

Benefit-cost Ratio

49.6.3 The National Council of Applied Economic Research (NCAER), New Delhi carried out benefit-cost analysis of pesticide treatment, based on experimental data furnished by State entomologists and plant pathologists[1]. For calculations, the various treatments given in the experiments were examined cropwise, and a few more frequently used treatments were selected for each of the crops. An average cost of treatment for a particular crop was then worked out based on the prevailing prices of pesticides. Labour and depreciation charges were added assuming that manually operated appliances were always used. According to the NCAER the benefit-cost ratio was markedly high in the case of seed treatment. It was 10 in cotton, 11.1 in wheat, 34.4 in jowar and 44.6 in paddy. However, this was essentially due to the low cost of seed treatment. The benefit-cost ratio was comparatively low in the case of post-sowing treatment because of its relatively high cost; even so, it was impressive. In the case of insecticidal treatment, it was 4.6 in paddy, 3.2 in wheat, 2.9 in jowar, 2.8 in cotton, 3.6 in sugarcane and 9.5 in potato, whereas in the case of fungicidal treatment it was 2.9 in paddy, 3.1 in wheat, 3.1 in cotton and 6.8 in potato. Thus, the net benefit per hectare was much higher in the case of post-sowing insecticidal than fungicidal treatments. This study had limitations in that the varia-

[1] Pesticides in Indian Agriculture, 1967 National Council of Applied Economic Research.

tions of yield between treated and untreated plots were not significant, precisely because pest infestation was not severe on the untreated plots. Other complicating factors, such as inadequate, excessive or untimed rainfall, weed competition, small number of experiments etc., made it difficult to gauge from the above analysis the benefit attributable exclusively to pesticide use.

49.6.4 Various research workers have attempted to find out the benefit-cost ratio of pesticide treatment, some of which have been quoted in Appendix 49.28 together with the pesticides used. It is seen that the ratios in the case of food crops and vegetables are lower, namely, 3 to 7.2 and 2.8 to 4.7 respectively, than in cash crops like cotton (2 to 13.5), sugarcane (3.4 to 14), and oilseeds (1.4 to 44). In jute and coconut the ratios are 4 and 2 respectively.

49.6.5 In reply to our questionnaire (Appendix 49.1), the States have indicated the benefit-cost ratios in the case of a number of crops. A summary of the replies is presented in Appendix 49.29. A comparative analysis of the ratios may be had in the case of paddy for which data from seven out of nine States are available. They vary considerably from 2.6 to 12.7 amongst the various States. For commercial crops like cotton, sugarcane, and oilseeds, the ratios vary widely from 3.1 to 10, and 5 to 16 and 2 to 10 respectively. The ratio is lower and the variation less in the case of wheat, e.g. 4 to 5. In regard to vegetables, the ratio is fairly high in most of the States which have responded. The other States have replied to the effect that the saving due to plant protection measures varies from 5 to 15 per cent.

49.6.6 The tabular statements, however inadequate, bring out clearly the benefits arising out of plant protection measures. The values vary because of the factors mentioned earlier, and particularly because the conditions of experiments and the methods of assessment are not identical, but vary markedly from one State to another and one worker to another. A more accurate estimate of the benefit-cost ratios should be obtained by carefully carrying out a large number of field experiments (result demonstrations) which would enable analysis of the data according to crops and treatments. For this type of work, some degree of technical knowledge or experience is required in diagnosing various pests and then selecting the appropriate and timely pesticide treatment. With fluctuations in the cost of pesticides and labour and return from produce, the benefit-cost ratio would vary. But even then such estimates are of value as a rough guide to assess the economics and benefits of pesticide treatment.

Impact on Cultivators

49.6.7 The use of chemicals for plant protection has increased considerably among the cultivators in view of the extension efforts made by the Government mainly and by other agencies. A comprehensive study of the awareness of cultivators in regard to adoption of plant protection measures was made by PEO in 1962.63[1]. According to this study, only 15.7 per cent of the respondents had knowledge of chemical measures for sowing and standing crops. But there is a wide gap between the awareness and adoption of chemicals, which is shown by the very small expenditure (2.2—2.5 per cent of inputs) on plant protection measures. Consequently, significant losses were caused to crops. "Pesticides Market Studies" undertaken by the Indian Institute of Management, Ahmedabad, in cooperation with the United States Agency for International Development (USAID) for the districts of Guntur, Ahmednagar, Mehsana and Shahabad show that on an average for a district a farmer does not spend more than Rs. 7.45 per hectare on pesticides for food crops, whereas he invests much more on the same item for cash crops. The highest expenditure is recorded in Guntur where cash crops predominate, and the lowest is in Shahabad.

49.6.8 In reply to our questionnaire (Appendix 49.1), most of the States have reported a fair degree of awareness on the part of farmers towards benefit of pesticide use. Karnataka, Gujarat, Maharashtra and West Bengal have recorded more use of pesticides for cash crops than others. Rajasthan, Bihar and West Bengal have mentioned the use of pesticides for high yielding varieties. Orissa and Maharashtra have stated that cultivators in the irrigated areas use larger quantities of fertilisers and hence more of pesticides, whereas in the rainfed or dry farming areas of Maharashtra cultivators undertake plant protection measures only when pest attack becomes virulent. Maharashtra, Karnataka and Bihar have affirmed that the increasing cost of pesticides seems to prevent smaller cultivators and those growing unirrigated crops from adoption of plant protection measures even though they are convinced of their efficacy. Haryana has reported about superstition often coming in the way of use of pesticides, although farmers are by and large fully aware of the benefits. But at the same time farmers in general are taking up pesticide use by seeing the results on farms of progressive farmers. Cultivators in Uttar Pradesh are reported to be well convinced as far as the control operations against insect pests, mites and rodents are

[1]Study of the Extension of Plant Protection Measures in Agricultural Production, 1968. Programme Evaluation Organisation, Planning Commission, Government of India.

concerned, but in the case of diseases the awareness exists only amongst the progressive farming community. In Jammu & Kashmir, only a few progressive farmers are fully aware of the benefit of pesticides.

49.6.9 The adoption of pesticides seems to be governed by economic factors. In general, the big farmers who use fertilisers adopt pesticides earlier than the small farmers. The commercialisation of crops encourages the use of purchased inputs and costly inputs are generally used on high income crops. Pesticide use is somewhat different from fertiliser use. In the latter case, the farmer uses fertilisers once he is convinced about its profitability, while in the former case although he may have been convinced regarding the efficacy of pesticides he may not use it unless he is forced in the face of pest attack. Prophylactic treatment is not common with the farmers except those who go for high value commercial crops. They are no doubt convinced of the benefit of pesticide use but the awareness of the magnitude of damage caused by pests seems to be lacking. In fact, the comprehension of farmers regarding pest affected areas or the lack of it, seems to govern their pesticide expenditure. It is, therefore, necessary to bridge the gap between awareness and actual adoption of measures for plant protection. This gap could be bridged by State departments through large scale extension methods. The State departments should review their plant protection setup, especially the extension unit, and streamline the organisation for this purpose. It is suggested that the pesticide industry should also undertake intensive efforts to educate farmers.

7 ASSESSMENT OF REQUIREMENTS OF AGRICULTURAL CHEMICALS

49.7.1 The use of plant protection chemicals started to become popular among the cultivators in India near about 1947-48 with the introduction of BHC and DDT. In the first Plan and to a greater extent in the Second Plan, increased food production was achieved mainly by extending area under irrigation and by organising various services for the farmers. The role of chemical inputs, particularly fertilisers, assumed great significance in the next phase of agricultural development. The new strategy for intensive cultivation which was adopted since 1966-67 aimed at achieving quick results by concentrating the limited resources on areas where they have the greatest chances of success, by use of high yielding varieties of seed and assured supply of other inputs. The importance of pesticides in this programme was recognised from the very beginning because of the other costly inputs involved and high economic returns. It was re-

alised that the use of pesticides could sustain the yield potential at a sufficiently high level.

49.7.2 Stimulated by the success achieved with BHC and DDT, the formulation industry was developed and many new pesticides were introduced through imports and marketed. The popularity of BHC and DDT led to the indigenous manufacture of BHC in 1952 and DDT in 1954. Since then there has been a remarkable progress in the manufacture of other chemicals. Fortytwo products of technical grade are being currently manufactured under different classes of posticides, as shown in Table 49.5 below.

TABLE 49.5

Technical Pesticides Manufactured in India[1]

Pesticide group	Name of pesticide
insecticides :	
chlorinated hydrocarbon	BHC, chlorinated terpene, DDT lindane, toxaphene
organophosphorus	dichlorvos, dimethoate, fenitrothion, malathion, metasystox parathion ethyl, parathion methyl, phosphamidon
others	lime-sulphur, nicotine sulphate, pyrethrum extract, thanite.
fungicides :	
metallic	barium polysulphide, copper oxychloride, cuprous oxide nickl chloride
non-metallic	sulphur colloidal, wettable and dust
organomercurial	organomercurials
thiocarbamates	mancozeb, zineb
dithocarbamates	ferbam, thiram, ziram
antibiotics	aureofugnin, streptocycline
rodenticides	coumafuryl, warfarin, zincphosphide.
weedicides	ammoniume sulphamat, 2,4-D 2, 4, 5-T
namaticides	metham N sodium
fumigants	aluminium phosphide, ED/CT, mixture, ethylene dibromide methyl bromide
molluscicide	metaldehyde

[1] Fifth Five Year Plan 1974-79. Report of the Task Force IV on Pesticides. Ministry of Petroleum Chemicals Government of India. New Delhi-8.

49.7.3 Table 49.6 gives the trend of consumption of major groups of indigenously produced pesticides (except fumigants) during the period 1954-1971. It illustrates the remarkable increase of insecticides consumption from 434 tonnes to 22,013 tonnes in 17 years.

TABLE 49·6

Trend of Consumption of Major Groups of Pesticides During 1954-71

(in tonnes of technical materials [1])

Pesticide groups	1954	1960	1965	1969	1970	1971
chlorinated insecticides.	434	6,729	10,186	16,516	20,500	20,365
organophosphorus insecticides	..	..	242	877	1,241	1,648
insecticides (total)	434	6,729	10,428	17,393	27,741	22,013
copper fungicides	..	595	1,310	358	360	865
sulphur fungicides	..	..	52	..	..	..
carbamate fungicides	..	..	74	574	1,342	1,144
organomercurials	..	3	44	29	32	12
other fungicides	..	..	..	25	40	46
fungicides (total)	..	598	1,480	986	1,774	2,067
herbicides (total)	..	..	..	12	15	30
rodenticides (total)	..	104	268	145	80	195
grand total	434	7,431	12,176	18,536	23,610	24,305

But the consumption of fungicides and herbicides increased from 598 tonnes to only 2067 tonnes and from nil to only 30 tonnes respectively. Of the insecticides, chlorinated hydrocarbons constitute a substantial proportion followed by the organophosphorus compounds. Amongst the fungicides the use of copper compounds and organomercurials has declined, but that of thiocarbamates has shown a steep increase.

49.7.4 The fungicides constitute a small proportion (about 8 per cent) of the total pesticides. Overall crop loss estimates on a global

[1] Based on production in tonnes of technical materials available from Director Genera of Technica development Annual Reports. No carbamate insecticides, acaricides and nematicides were used upto 1971

basis[1] suggest that loss due to diseases is almost as high as that due to insert pests. Consequently, the diseases deserve much greater attention than what has been paid so far. The fight against fungi and bacteria is beset with more difficult problems than that against insects. Since the former belong to the plant kingdom the weapons must be more specific. Moreover, the pathogens multiply much faster and are of submicroscopic dimensions, making it often difficult to detect them at early stages without expert help. Most of the early fungicides are prophylactic in action. Recently a number of curative fungicides having selective action on fungi have become commercially available. They are broadly categorised as systematic fungicides and belong to different chemical groups, namely, benzimidazole and thiophanates, oxathiins and carboxyanilides, pyrimidines, piperazines and azepines, organophosphorus compounds and morpholine derivatives. The Indian pathologists are already aware of the importance of fungicides in plant protection especially fruit trees and plantation crops. But the potential of fungicides in increasing productivity of cereals, oilseeds and vegetables has not been fully realised. However, in the Fifth Plan proposals the pattern of consumption is as in the Table 49.7 below.

TABLE 49·7

Expected Consumption Pattern of Pesticides in 1973-74 and 1978-79[1]

	Percentage consumption by weight	
	1973-74	1978-79
Insecticides	72·6	70·7
fungicides	22·4	19·3
weedicides	3·3	7·3
rodenticides	0·4	0·4
fumigants	1·3	2·3

A large number of systematic fungicides are now available, out of which proper choice based on well designed experiments should be able to provide control measures suitable for seed infection, various stages of crop growth, and for grains, fruits and vegetables in storage and transit.

1. Mehta P. R. 1975 Fungicidal Umbrella Advances in Mycology and Plant Pathology. Professor R. N. Tandon's Birthday Celebration Committee.

49.7.5 There is another group of chemicals, broadly classed as herbicides or weedicides which should get greater consideration than what they are having at present.[1] The word consumption figures are : weedicides 42%; insecticides, 34%; fungicides, 18% and the rest, 6%. From Table 49.7, it would appear that in India weedicides have just made a start. Increased fertiliser use is an essential part of the new strategy of crop production; so are the increased uses of pesticides, to sustain the enhanced production. Weeds compete more favourably than insect pests and diseases with crop production and hence the global rise in herbicide or weedicide consumption. The trend is obvious, but the question that is uppermost in the minds of ecologists and environmentalists is whether this vicious circle should be allowed to continue or not. Herbicides or weedicides belong to diverse chemical groups such as the carbamic acid esters; anilines and ureas; ethers and phenols; acids; nitriles; amides and thioamides; and heterocyclics, e.g., benzimidazoles, quinazolines, dipyridyls, pyridazones, triazines and uracils. Weedicides are required to possess a high degree of selectivity and hence their presence in fairly large number in the market. Intensive agriculture demands greater use of weedicides and each new situation often calls for a new choice.

49.7.6 Besides increased production within the country, plant protection chemicals have been imported to supplement indigenous production. Information on the import of pesticides does not specify all the chemicals imported, but many are simply mentioned as 'Pesticides Not Elsewhere Specified (NES)', 'Agriculture Insecticides NES', 'Other weedicides and killing agents', 'Weedkiller NES', Other etc. An attempt was made to obtain more systematic and authentic information on the consumption with the help of a questionnaire issued to the States (Appendix 49.1). Table 49.8 gives a summary of the information obtained in reply to this questionnaire. From the table it is found that none of the States appear to maintain a complete record of the types of chemicals and quantities consumed annually. Nor is there uniformity in the maintenance of records. Andhra Pradesh (1970-71 to 1972-73), Bihar (1969-70 to 1972-73), Karnataka (1969-70 to 1973-74), Tripura (1969-70 to 1971-72) and Manipur (1960-61 to 1971-72) have indicated yearwise consumption of pesticides in terms of formulation products, but the formulation for all the chemicals is not mentioned. Gujarat (1963-64 to 1972-73) has indicated pesticides in terms of their active ingredients, Haryana (1966-67 to 1971-72) and Orissa (1960-61 to 1971-72), have not clarified

1. Majumdar, J. C. 1974 Some Recent Advances in Research & Development in the Pesticide Industry Indian Chemical Manufacturers, Bombay Regional Office, Bombay.

whether the chemicals are technical materials or formulated products. No information could be obtained from the rest of the States. Hence, from the available information, neither the position in regard to use of pesticides nor its trend during the years could be ascertained.

49.7.7 It is important that the States shall maintain a complete yearwise record of all the plant protection chemicals actually being consumed. These data should not only refer to records kept at the governmental level but should also include those distributed through private and other agencies. States do use formulated products and it is necessary that they are recorded by all in a uniform manner. A systematic record should not only give the amounts of insecticides, fungicides, herbicides, rodenticides, etc., but also state the various groups of chemicals, as well as individual chemicals. The need to maintain such records with the DPPO&S cannot be overemphasised. Information thus obtained for a number of years would help the Government/industries in planning to meet the bulk of the country's demand of various chemicals through indigenous production and, if necessary, import.

TABLE 49·8

Summary of Information Obtained on Trend in Use of Plant Protection Chemicals by Different States

State	Summary of information
1	2
Andhra Pradesh	total consumption in terms of dust formation in tonnes for 1956 to 1960-61; yearwise total dust formulation from 1961-62 to 1969-70; yearwise use of chemicals formulations for all not mentioned in tonnes and litres from 1970-71 to 1972-73.
Assam	no information given.
Bihar	yearwise use of chemicals, formulations for all not mentioned, in kg./litre from 1969-70 to 1972-73.
Gujarat	yearwise consumption of chemicals in kg. active ingredients from 1963-64 to 1972-73.
Haryana	yearwise use of chemicals in kg./litre from 1966-67 to 1971-72; only names of chemicals mentioned.

TABLE 49.8 (contd.)

1	2
Himachal Pradesh	yearwise consumption of total chemicals in kg./litre from 1966-67 to 1972-73.
Jammu & Kashmir	nominal quantities consumed during past years.
Maharashtra	yearwise consumption of chemicals in tonnes/litre 1963-64 to 1972-73; formulations for all chemicals not mentioned; item on other pesticides constitutes about 50% which has not been specified.
Manipur	yearwise consumption of chemicals in tonnes from 1960-61 to 1971-72; formulations for all not mentioned.
Karnataka	yearwise consumption of chemicals in tonnes/litres from 1969-70 to 1973-74 formulations for all not mentioned.
Orissa	yearwise consumption of chemicals in tonnes from 1960-61 to 1971-72; only names of chemicals mentioned.
Rajasthan	yearwise consumption of total insecticides, fungicides and rodenticides in tonnes from 1969-70 to 1971-72.
Tripura	yearwise consumption of chemicals in tonnes from 1960-61 to 1971-72, formulations for all chemicals not mentioned.
Uttar Pradesh	yearwise consumption of chemicals in tonnes as total dusts/wettable powders/emulsions/rodenticide seed treating chemical from 1960-61 to 1971-72.
West Bengal	yearwise consumption of chemicals in tonnes/litres, from 1960-61 to 1972-73; formulations for all not mentioned.

49.7.8 The Pesticides Association of India maintains all-India consumption figures, based on the materials sold by the pesticides industry as well as the Government from stocks of domestic production and imports. The total sales are assumed to be consumed. But there is no breakup of the consumption data on the basis of crops or regions or groups of pesticides. Table 49.9 gives from 1955-56 to 1971-72 the total cropped area, the trend of total consumption of pesticides in terms of technical material and the trend in consumption of pesticides in grams per hectare of the gross cropped area.

Referring to the table it would be seen that initially the consumption of pesticides in the country was very low, so much so that by the end of the First Plan, only 2,350 tonnes in technical grade was consumed. By the end of the Second Plan there was a remarkable increase in the total consumption to the extent of 267 per cent over that consumed by the end of the First Plan. The rate of increase was, however, variable. By the end of the Third Plan, the increase was to the extent of 70 per cent over that of the Second Plan. Subsequent annual plan periods maintained more or less the same trend but the increase in 1968-69 was 34 per cent. Available figures for the first three years of the Fourth Plan show similar increase in consumption.

49.7.9 Even though the rate of consumption of pesticides varies, that of consumption per unit of gross cropped area has been on the increase (cf. col 4, Table 49.9). In 1955-56, 15.9g pesticides per hectare was consumed which in 1971-72 rose to 190.1g per hectare. Comparing this with the consumption figures of developed countries, it is still very low as shown below.[1] But since all the cropped area is not covered by plant protection chemicals, the consumption per hectare, wherever used, must be much higher.

Japan	10,790 g/ha
Europe	1,870 g/ha
USA	1,480 g/ha

1. Pesticides Production & Consumption, 1972 Pesticides Association of India, New Delhi.

TABLE 49.9

Trend in Consumption of Pesticides(technical) During the Period 1955-56 to 1971-72

Year	Total cropped area (m.ha)[1]	Total consumption[2] (tonnes)	Consumption (g/ha of gross cropped area)
1	2	3	4
1955-56	147.3	2350	15.9
1960-61	152·8	8620 (+267)**	56.4
1961-62	156·2	10300 (+19)*	65·9

TABLE 49.9 (contd.)

1	2	3	4
1962-63	156·8	9890 (—4)*	63·1
1963-64	157·0	11030 (+11)*	70·3
1964-65	159·2	12060 (+9)*	75·7
1965-66	155·4	14630 (+21)* (+70)**	94·2
1966-67	157·4	17137 (+17)*	108·9
1967-68	163·7	20900 (+22)*	127·7
1968-69	159·5	19580 (—6)* (+34)**	122·6
1969-70	163·4[3]	20650 (+5)*	126·1
1970-71	165·1[4]	24314 (18)*	147·3
1971-72	164·0[4]	29535 (+21)*	180·1

Note: Due to changes in coverage and methods of estimation, the figures are not strictly comparable over time

1. Directorate of Economics & Statistics, Ministry of Agriculture and Irrigation, 1972.
2. Pesticides Association of India, 1972.
3. Agriculture in Brief, 13th Edition, March, 1974.
4. Brochure on Area and Production of Principal Crops, 1971-72, 1975 Directorate of E&S.

* Figures in paranthesis show the percentage consumption during the year. ** Figures in parenthesis show the percentage increase in consumption over the previous plan

49.7.10 According to the assessment of the Pesticides Association of India the pesticides consumption during 1970-72 on food crops which constitute 72 per cent of the gross cropped area, is only 35 per cent of the total pesticides sold. Cash crops, oilseeds and plantation crops continue to be the major consumer of pesticides in the country. Even though the economic returns in the case of these crops are favourable there appears to be lack of trained extension workers who would educate the farmers on the need and value of pesticides for cash as well as food crops. There is, therefore, need for a well organised extension service whose staff should educate the farmers on the usefulness of pesticides in the promotion of overall agricultural

production and productivity. The staff engaged in such extension work should be adequately trained to identify the insect pests and diseases of crops and undertake effective demonstrations in the farmers' field. This extension network should not only be organised at the Governmental level, but the pesticides industry should also collaborate in such work.

Requirement of Chemicals

49.7.11 Two factors are patently responsible for increasing the demand for pesticides: (a) the growing emphasis on using plant protection measures; and (b) the increased area under high yielding varieties which, being relatively more susceptible to pests than the traditional varieties, require considerable amounts of plant protection chemicals. Accordingly, the indigenous capacity for production of chemicals has been gradually increased. But the demand being greater than what could be produced in the country has to be met by imports. Imports have been further necessitated by the availability of chemicals of higher potency in the foreign markets. Till the end of the Third Plan it was considered that only a certain percentage of the gross cropped area requires to be covered under plant protection. With the beginning of the Fourth Plan four categories of chemicals treatments have been recognised. The following breakup shows[1] corresponding to these categories, the estimated areas to be covered at the end of the Fifth Plan:

seed treatment	21·0 million hectares
rat control	12·0 million hectares
weed control	4·5 million hectares
intensive treatment on surface and soil pests	62·5 million hectares

A cropwise breakup of these targets appears in Appendix 49.30.

49.7.12 A compilation of States' estimates on the future trend in consumption (requirement) of pesticides received in reply to our questionnaire is given in Appendix 49.31. From this compilation it is seen that there is no uniformity in the States' replies. Thus, Andhra Pradesh (1972-73 to 1978-79) and Karnataka (1974-75 to 1978-79) have given the requirement in terms of technical material. Maharashtra(1972-73 to 1976-77) has given in terms of formulated products. Bihar (1974-79, 1979-84 and 1984-89) and Uttar Pradesh

1. Fifth Five Year Plan (1974—79). Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India, New Delhi.

(1972-73 to 1978-79) have mentioned total pesticides in terms of the chemical groups. Others have not clearly stated the forms of the chemicals, whether formulated products or technical grade materials. Hence, not given a rough estimate is possible of the requirement of chemicals on the basis of the information given. No information was available from Assam, Gujarat and Tripura. It is essential that all the States record their requirements on a uniform basis and report accordingly. The requirement should not only include those reported at the Government level but also those by other agencies.

49.7.13 The bases on which the annual targets for plant protection chemicals and evaluation of achievements have been made by States are summarised in Appendix 49.32. It is seen that the most common method of assessment is on the basis of last year's achievements for targeted coverage under plant protection. While Gujarat, Karnataka, Manipur and Orissa, and probably West Bengal have made a mention about the areas to be under high yielding varieties, none of the other States have done so. It may, however, be assumed that the high yielding varieties have been the basis for assessing the requirement of chemicals. Besides, the States have included other factors, such as cropping patterns, strength of staff and plan of endemic areas of pests (Bihar), cultivators' choice, epidemic cycles and climatic factors, market trend and price (Gujarat), and supply and availability (Orissa and Rajasthan). Karnataka has set the requirement at 20 per cent or more above the previous year's consumption both under high yielding varieties and other normal programmes. Hence, it is observed that there has been no uniform and adequately scientific basis for estimating the requirement of chemicals.

49.7.14 It is, therefore, suggested that for a proper assessment of the requirement of chemicals the basis could be the use of pesticides according to the cropwise pest problems and recommended plant protection practices. From whatever information has been available, we have attempted to assess the requirement of pesticides by the end of the Fifth Five Year Plan (Appendix 49.33), broadly taking into consideration the three aspects, namely, (a) pest problems of major food, cash, plantation, fruits and other crops; (b) choice of chemicals and dosage as per State Government's plant protection schedules; and (c) preference for indigenously produced pesticides. The total requirement of chemicals by the end of the Fifth Five Year Plan has been estimated at about 0.105 million tonnes in terms of technical materials. The likely gap between the estimated requirement and estimated total capacity is about 32,000 tonnes, which has to be filled up by increasing indigenous capacity. The assessment on the cropwise requirements of insecticides and fungicides has been

made, firstly, by taking into consideration the Statewise and cropwise serious and moderate insect pests and diseases from literature; secondly, common chemicals with dosages recommended by States;* and thirdly, assuming that insect pests or diseases would affect not more than 40 per cent of the area targeted under various crops.**

49.7.15 The requirement of seed treating chemicals has similarly been assessed on the basis of insect pests and disease problems assuming that the entire quantity of seed required to cover the targeted area should be treated with chemicals. Information on the cropwise weed problems was not available from all the States. Hence, the requirement of weedicides for the country as a whole has been calculated by assuming the dosage and chemicals to be the same for the rest of the targeted area as those for the States for which data were available.

49.7.16 Information on the cropwise problem of rodents has not been available. Hence, for assessment of requirement it has been assumed that 40 per cent of the targeted area would have to be treated with rodenticides. Regarding nematicides, 0.01 per cent of the targeted area for wheat and sugarcane has been taken into consideration based on the available information and probability of use of these chemicals in future. Here also an assumption similar to that mentioned in the previous paragraph has been made.

49.7.17 On the basis of similar assumptions made for the assessment of 1978-79 requirement of plant protection chemicals, that of 1985-86 has been estimated. It has been further assumed that the coverage under different groups of crops would remain identical and that the same chemicals and dosages would be used as in 1978-79. The estimated figures are given in Table 49.10 from which the total requirement of plant protection chemicals in 1985-86 comes out to be 0.14 million tonnes.

The estimates are too approximate because of the lack of necessary data and the *ad hoc* assumptions made for the calculations. By 1978-79 more reliable data are likely to be available if the States report their requirements in the manner suggested in this section (paragraph 49.7.18). A more accurate estimate for 1985-86 and subsequent periods would then be possible.

49.7.18 An important factor which has been observed is that there appears to be no relation whatsoever between the recommended chemicals in the plant protection schedule and the consumption and

* Parathion and endrin were left out of consideration in view of the possibility of their being out of use in the future.

** The targeted areas for the five major food crops have been taken from Annexure XI of the draft Fifth Five Year Plan, 1974—79, Volume II.

TABLE 49·10

Total Requirement of Plant Protection Chemicals in 1985-86[1]

Crops	Total gross area (Mha)	Total area under P.P. chemicals	Percentage area under P.P. chemicals
cereals	51·00	51·00	100
pulses	27·00	3·68	13·63
oilseeds	22·00	3·01	13·66
sugarcane	4.20	3·82	90·90
cotton	12·00	4·60	38·31
others	21·80	6·64	30·48
	total	72·75	

Total requirement on the basis of 1978-79 estimate $= \frac{72 \cdot 75 \times 0 \cdot 105}{55} = 0 \cdot 14$ million tonnes.

[1]. Perspective for Agriculture in India 1968-69 to 1985-86, 1967, p. 6. Planning Commission, Government of India.

requirement of chemicals as received from the States. Most of the States, for which information is available, have shown consumption of chemicals which have not been included in the schedules. Similar is the case with the requirement. It is recommended that the present plant protection schedules be revised immediately, making it obligatory to revise them every two years. In assessing the requirement another important factor for consideration is the adoption of certain preventive or propylactic measures more commonly in the case of commercial crops such as cotton. If the farmers become more conscious in this respect, use of chemicals for plant protection would indeed be small. It has been further observed that the recommended plant protection schedules made available by the States do not conform to the pest problems as published in the literature. It is, therefore, suggested that the State surveillance agencies should maintain records of cropwise pest problems together with the time and intensity of attack. In the long run this information would be of use not only to assess more exactly the requirement of chemicals but also to plan control operations more systematically.

49.7.19 Marketed pesticides bear different trade names, even though they may belong to the same chemical group. Their prices and performances vary according to the benefits derived by the

users. There should be a rational approach to assess their relative merits based on performance and cost of treatment. The type of equipments needed to undertake plant protection measures, such as, seed treatment, dusting, spraying, etc., and their availability are factors to be taken into account. The location of endemic areas is important for effective plant protection operations. There should be provision for sudden outbreaks, for which an uptodate inventory of available stocks both with the Government and private agencies is imperative. It is suggested that the plant protection units of the States should be reorganised to collect and evaluate data on pest problems, cropwise and seasonwise; of the endemic areas, if any; and of the pestwise requirements of chemicals. They should accordingly be armed with the necessary equipment, machinery, trained personnel and other facilities to fight sudden outbreaks and emergency situations.

8 BASIC RAW MATERIALS, KNOWHOW AND INDIGENOUS AVAILABILITY

49.8.1 With the setting up of a plant for manufacturing BHC in 1952, followed by DDT in 1954, indigenous manufacture of technical grade pesticides got started. At present 42 pesticides, under various categories (Table 49.5) are being produced in the country with indigenously available raw materials and also from imported raw materials. The main raw materials and their quantities required per tonne for the manufacture of the major pesticides are given in Appendix 49.34. The indigenous availability of raw materials, knowhow and R & D efforts in regard to the most commonly used pesticides are discussed below.

Chlorinated Hydrocarbons

49.8.2 This group of chemicals includes aldrin, BHC, chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor, lindane, citicide (chlorinated terpene) and toxaphene (chlorinated camphene). Other than BHC and DDT which are already being manufactured in the country, the production of aldrin, chlordane, dieldrin, endosulfan and heptachlor is based on hexachlorocyclopentadiene (HCCP) which is made by chlorination of cyclopentadiene, the latter constituting the main raw material for this series. The knowhow for the chlorination of cyclopentadiene to make HCCP is not available. Also, the knowhow for making butanedioldiacetate from butadiene which is the main raw material in the manufacture of endosulfan is not available. It is understood that the National Chemical Laboratory (NCL), Poona,

would shortly take up this work. As and when indigenously produced substitutes become available the use of products like endrin, which are definitely known to be seriously pollutants, would have to be gradually discontinued.

Organophosphates

49.8.3 A large number of insecticides under this group are being tested and tried in the country, some of which are still in the experimental stage. For their manufacture the basic raw materials, phosphorus pentasulfide and phosphorus trichloride, are produced indigenously. But the other four basic primary intermediates, maleic anhydride, ethyl mercaptan, metacresol and orthophenylenediamine, are still not available in the country, and are, therefore, to be imported till their indigenous production is established. Table 49.11 gives a list of thirteen chemicals, seven of which can be made with the help of the above four basic primary intermediaries. All other raw materials required are indigenously available and hence not listed in the table.

49.8.4 Of the four basic primary intermediates, the resin industry requires large quantities of maleic anhydride and metacresol, and letters of intent for their manufacture have already been issued. Ethylmercaptan which is not required by any other industry can be produced by the reaction of ethylene with hydrogen sulfide. From the production of phosphorus intermediates, dimethyldithiophosphate and diethyldithiophosphate, the byproduct hydrogen sulfide could conveniently be utilised provided ethylene is made available at the same site.

TABLE 49·11

Primary, Penultimate and Other Chemicals Required for Manufacture of Organophosphates[1]

(Kg/tonne)

Insecticide	Penultimate* intermediates		Primary Intermediates		Others
	phosphorus	others	phosphorus pentasulfide	ethylmercaptan	
1	2	3	4	5	6
malathion	I—640	..	560	..	maleic anhydrid (400)

TABLE 49.11 (Contd.)

1	2	3	4	5	6
dimethoate .	I—1150	methyl chloroacetmide (780).	1000	..	..
phenthoate .	I—617	ethylphenyl acetate (705)	530	..	..
menazon . .	I—937	..	816	..	..
thiometon .	I—685	ethylmercaptoethanol (540)	610	400	..
disulfoton .	II—680	Do. (450)	510	330	..
metasystox .	III—930	Do. (615)	..	450	..
phorate . .	II—1090	..	812	410	..
phosalone .	II—560	N-chloromethyl 6-Chloro-3-benzoxa-zolone (650)	420	..	..
fenitrothion .	III—540	nitrometacresol (625)	..	..	metacresol (670)
parathion (methyl)	III—7770	paranitrophenol (670)	..	..	..
parathion (ethyl)	IV—725	Do. (535)	..	..	..
quinalphos .	IV—1000	2-hydroxy-quinoxaline (540)	..	..	orthophenylenediamine (580)

[1] Fifth Five Year Plan (1974-79). Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India.

*I. Dimethyldithiophosphate; II. Diethyldithiophosphate; III. Dimethylthionophosphoryl chloride; IV. Diethylthionophosphoryl chloride.

Priority should be given for developing this knowhow. Orthophenylenediamine required for the production of organophosphates constitutes the starting intermediate for making the fungicides, benomyl and thiophanate. The knowhow for its production can be developed from orthonitrochlorobenzene which is to be produced by the Hindustan Organic Chemicals Limited (HOC), Rasayani (Maharashtra)

Carbamates

49.8.5 Carbaryl and carbofuran are the two main items under this category. Table 49.12 gives the requirements of intermediates. The technology for alphanaphthol is similar to that for betanaphthol produced indigenously for the dyestuff industry. Methylisocyanate,

TABLE 49·12

Intermediates (Kg./tonne) of Carbamates[1]

Insecticides	Alphanaphthol	Methyl isocyanate	Catechol	Methally chloride
carbaryl	800	320	..	..
carbofuran	..	290	1,160	950

1. Fifth Five Year Plan 1974—79. Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India.

the common intermediate required for making carbaryl and carbofuran, is made by condensing phosgene with monomethylamine. Upto the phosgene stage, the capacity has been licenced and is being installed. The current supply of monomethylamine, which is also being used for the manufacture of dimethoate, from the Fertiliser Corporation of India (FCI), Trombay, is adequate. Carbofuran has been introduced very recently in the country and the present level of consumption is very low. Moreover, the process of manufacturing is complicated and expensive. For making carbofuran, two main intermediates, catechol (or pyrocatechol) and methallyl chloride are required. Taking the world market as a whole, catechol is in short supply. The quantity of this chemical available in the country at present is too small for production. A process for its synthetic manufacture would have to be developed. Being a petrochemical by product, methallyl chloride is available in the world market. Its synthesis requires chlorination of isobutylene which would be a byproduct with the Indian Petrochemical Corporation Limited (IPCL), Baroda. This could be taken up as a research and development project along with chlorination of cyclopentadione and butadiene as mentioned under chlorinated hydrocarbons.

Fungicides

49.8.6 Only three intermediates, 2-mercaptoethanol, thiophenol and orthophenylenediamine, are required to be imported for the manufacture of seven modern fungicides listed in Table 49.13. All other raw materials required are indigenously available. Orthophenylenediamine is also required for the manufacture of quinalphos (cf. Table 49.11). Hence, only 2-mercaptoethanol and thiophenol are to be imported till their local manufacture is established. Research and development on these two have to be strengthened. The knowhow

for making 2-mercaptoethanol may be developed along with ethylmercaptoethanol required for organophosphates (cf. Table 49.10). The technology for thiophenol may also be developed.

TABLE 49·13

Intermediates of Fungicides[1]

Fungicide	Main intermediates	Kg/tonne
1. penthachloronitrobenzene (PCNB) .	nitrobenzene	500
2. fentin hydroxide	stannic chloride	1800
3. fentin acetate	Do.	2100
4. vitavax	2-mercaptoethanol .	410
5. benomyl	orthophenylenediamine	N.A.*
6. thiophanate	Do.	N.A.*
7. hinosan	thiophenol	760

1. Fifth Five Year Plan 1974-79. Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India.
* N.A. Not available.

49.8.7 The National Chemical Laboratory (NCL) has already developed the knowhow for PCNB on a pilot scale. In collaboration with the Regional Research Laboratory (RRL), Hyderabad, research and development on fentin hydroxide, fentin acetate and vitavax are in progress. It is expected that the NCL is going to take up work on hinosan. Thus, within a few years, the knowhow may be available for practically all the items listed in Table 49.13 together with the intermediates required. A few thiocarbamate fungicides are being manufactured in the country. More production of this group of chemicals in the country would save valuable foreign exchange.

Weedicides

49.8.8 Table 49.14 gives a list of weedicides with their intermediates which are not available indigenously. Of these only two, 4,4-bipyridyl (for paraquat) and propionic acid (for dalapon and propanil) deserve top priority for indigenous production in order to achieve self-sufficiency in this group. The technological knowhow for the development of paraquat is available. Among other intermediates listed, 3,4-dichloraniline is a dyestuff intermediate. Its manufacture requires

TABLE 49·14

Requirement of Main intermediates in kg per tonne of Weedicides and Herbicides[1]

Woodicide	Main intermediates	Requirement kg/tonne
paraquat	4,4-Bipyridyl	N.A.*
dalapon	propionic acid	640
alachlor/butachlor	2,6-diethylaniline	800/700
propachlor	N-isopropylaniline	710
propanil	3,4-dichloroaniline	820
nitrofen	locally avialable	N.A.*
diuron	3,4-dichloroaniline	870
monosodium methanearsonate/Disodium methanearsonate (MSMA/DSMA)	arsenic trioxide	900

[1]. Fifth Five Year Plan (1974-79). Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India.

*N.A. Not Available.

pure orthodichlorobenzene which has to be imported. Arsonic trioxide is imported in large quantities for other industries. Both alachlor and butachlor require 2,6-diethylaniline which is manufactured by means of a rather complicated technology. Hence, its import would continue for a long time. Propachlor which belongs to the same class of herbicides offers a decided advantage in that its intermediate, N-isopropylaniline, can be made very easily from locally available aniline and isopropanil or acetone. Since, however, it is used in very limited situations, it cannot substitute alachlor and butachlor. The development of processes for dalapon, propanil, nitrofen and DSMA is in progress at the National Chemical Laboratory (NCL).

Acaricides

49.8.9 The two items suggested are: (a) tedion and (b) kelthane. For their manufacture no imported intermediates are required. The Regional Research Laboratory (RRL), Hyderabad is developing a 2-step process for tedion from locally available raw materials. The Indian Agricultural Research Institute (IARI), New Delhi has already developed a process for kelthane which is going to be scaled up by the NCL. Poona.

Nematicides

49.8.10 These include dibromochloropropane (DBCP) (DD)*/ nemex. telone. etc. and are all essentially byproducts of the manufacture of allyl chloride which is an intermediate for epichlorohydrin and synthetic glycerol. No imported chemicals are needed and the RRL, Hyderabad is already fairly advanced in developing the knowhow for this group of chemicals.

Plant Growth Regulators

49.8.11 To this group of chemicals belong (a) cycocel, (b) gibberellic acid and (c) ethephon (ethrel). For manufacture of gibberellic acid based on indigenous raw materials, the letter of intent has been granted. The NCL is developing knowhow for ethephon. All raw materials required are indigenously available.

49.8.12 The cost of indigenously manufactured products is higher than the international prices as indicated in Table 49.15 whether manufactured with indigenous raw materials or with imported ones. The idea of indigenous manufacture of pesticides is primarily to attain self-sufficiency, save foreign exchange and make available the products at the proper time and at a lower cost within easy reach of the farmers. The Government allows the import of chemical raw materials and intermediates at 20 per cent customs duty to encourage basic

TABLE 49·15

Indian and International Prices of Selected Pesticides and Chemicals[1]

(Rs. per tonne)

Name of material	Indian price	International price
DDT	5,300	3,405
BHC	1,300	1,770
malathion	13,200	6,800
parathion	20,000	8,500
phenylmercury acetate (PMA)	1,50,000	92,280
copper oxychloride	8,000	3,600
dimethoate	60,000	25,956
solvent (per kilolitre)	1,000	450

*1,2-dichloropropane and 1, 3-dichloropropene.

1. Basic Chemicals. Pharmaceuticals and Soaps Exports Promotion Council, Bombay.

manufacture. The import of chemical intermediates, if available indigenously, is banned to help the local manufacture of basic pesticides. In many cases, the prices of raw materials of indigenous origin are generally much higher than the international prices, as a result of which the costs of indigenous manufactured products are high. In such cases, either the Government allows import of chemicals from the cheapest source, or makes them available at a subsidised rate. It is, therefore, necessary to have complete costing before any manufacture is undertaken in the country. Further, there should be a probe in depth to find out why the indigenous manufactures are so much costlier than the international products. No evidence is available in the country to develop newer pesticides either by the industry or research institutions. So far, for almost all the products being manufactured indigenously, the knowhow was developed in foreign countries, namely, USA, West Germany, Switzerland, Japan and U.K. Moreover, it seems that this trend is likely to continue for some time to come. Whatever research efforts are being made by the industry are primarily directed towards formulation of products. Efforts are needed to develop knowhow for the manufacture of intermediates, active technical pesticides and their formulation. The National Chemical Laboratory, Poona, Regional Research Laboratories at Hyderabad and Jammu, Indian Agricultural Research Institute, New Delhi, Central Food Technological Research Institute, Mysore, and the Industrial Texicology Research Centre, Lucknow have considerable joint R&D programmes in pesticides, as a result of which thirtyseven products (some of which are mentioned above) are at different stages of commercialisation[1]. The risk involved in marketing a new product is so great that industries generally prefer tried pesticides and shy away from new ones.

Natural Sources of Pesticides

49.8.13 The naturally occurring pesticides are derived from vegetable origin either as such or chemicals synthesised from them. These are contact insecticides and were used in the past for controlling aphids, scale insects, mites, insect eggs, cattle grubs, mealy bugs, lice, flies and mosquitoes. The more important naturally occurring insecticides are nicotine, pyrethrins, rotenone, and petroleum oils. They are generally unstable towards light, air, moisture and alkali and the residues deteriorate rapidly after application. High cost of application and nonavailability in sufficient quantity are some of the stumbling blocks in their usages as plant protection chemicals in agriculture, but they

1. Baldev Singh, D. Bhusan & R.C. Adlakha 1975, *Pesticides* 9. 23—39.

have advantages, unlike most of the synthetics, of selectivity, efficiency and easy biodegradation. Research work on naturally occurring pesticides and on products synthesised from them and having desirable stability should therefore, be intensified.

9 FERTILISER PESTICIDES MIXTURE

49.9.1 In the case of most crops the critical stages of growth which coincide with the maximum uptake of nutrients, often happen to be the vulnerable stages of pest attack. The application of certain fertiliser chemicals, *e.g.* urea, on such occasions in spray form may be combined with pesticide chemicals, thereby saving application cost. Large scale demonstrations, mostly under rainfed conditions, have shown the effectiveness of combined sprays on such crops as jute, wheat and paddy. These combined sprays have not only helped in controlling pests but have also shown increased yields. All the combined sprays are with urea, which being nonionic, is compatible with the commonly used pesticides. In some instances mixing produces synergistic effect. Experiments carried out with wheat under rainfed conditions in Kota District, Rajasthan[1] have demonstrated that the average yield increase, using 20 per cent urea solution with pesticides, amounts to 30 per cent. With 40 per cent urea, the average increase has gone up to 45 per cent. These increases are equivalent to benefit-cost ratios of 3.3 and 4 respectively. Similar results obtained from Madhya Pradesh have shown an average increase of 12.5 per cent in yield of paddy by the use of fertiliser—pesticide mixture.

49.9.2 The combined fertiliser pesticide sprays have so far been confined to certain localised areas having large contiguous blocks. Possibilities of such combined sprays have not been explored in small areas having fragmented lands. Fertiliser pesticide mixtures, if formulated, would help small and marginal farmers not only in controlling pest problems but also in increasing yields of crops without resorting to separate application. Also, as a ready-to-use mixture, these can be applied like any other spray chemical following specific instructions for application.

49.9.3 Since the systematic pesticides can be absorbed through foliage as well as by roots, the possibility of applying fertiliser pesticide mixtures to the soil should be investigated. Apart from urea, the possibility and desirability of mixing other nitrogenous, phosphatic and potassic fertilisers, most of which are ionic,

1. Fredrickson C.J. 1971. Foliar Fertilization in relation to pest control. *Participant J 5* (7) : 4—

are matters of further investigation. For example, studies should be undertaken to find out (a) the conditions for a homogenous mixture; (b) reactions which affect the efficacy in the mixture of either the plant nutrient or the protection chemical or of both, and (c) keeping qualities of the mixture in storage.

Method and Time of Application

49.9.4 Fertilisers are mostly applied to the soil, occasionally sprayed, like urea, triple superphosphate and sulphate/muriate of potash, whereas pesticides, besides seed treatment, are mostly dusted and/or sprayed on the crops. Soil applications is done when it becomes necessary to control soil pests and when granular formulations are used. Application and dosage of fertilisers depend on the soil and crop conditions, crop variety and its growth stage. With the exception of phosphatic and potassic fertilisers, which are normally applied as one basal dose, nitrogenous fertilisers are often applied in split doses. The time of application of fertilisers, even though important, is far more flexible than that of pesticides, for which it is crucial. Moreover, unlike pesticides, fertilisers are applied in large dosages.

49.9.5 It is common knowledge that pesticides use per unit area has not kept pace with increased use of fertilisers. The pesticides are predominantly used for curative and rarely for prophylactic purposes except on cash crops. Fertiliser pesticide mixtures may somewhat compulsorily increase the use of pesticides. Again, unlike fertilisers, except nitrogen which is used in split doses, pesticides are ordinarily applied several times. Consequently, only some of the pesticides may find place in fertiliser pesticide mixtures, because there is no broad spectrum pesticides which would kill all kinds of pests appearing at different stages of crop growth. Further, the same fertilisers would be applicable to all crops, whereas pesticides would vary considerably from one crop to another. These are some of the factors which would perhaps limit the use and effectiveness of fertiliser pesticides mixtures.

49.9.6 While dealing with the quality aspects of fertilisers in our Interim Report (1971) on Fertiliser Distribution, we have suggested that "the ISI should bring out standards for fertiliser—pesticides mixtures in anticipation of their becoming a part of the future consumption pattern alongside the use of more and more complex granulated fertilisers". It is further suggested that a committee of representatives from the agricultural universities, ICAR, IARI, DPPQ &S, ISI and the fertiliser and pesticide industries should be formed to take up a thorough study of fertiliser pesticide mixtures in relation to the pattern of future consumption of both fertilisers and pesticides,

changes in cropping patterns under various agro-climatic conditions, pest complex, and cost of application.

10. RESIDUAL TOXICITY AND HAZARDS OF PESTICIDES

49.10.1 A classification of chemicals according to their use, physical condition and grade is given in Appendix 49.35. All the chemicals have been classified according to their specific use into several broad categories, namely, insecticides, fungicides, weedicides, nematicides, acaricides, rodenticides, fumigants, antibiotics and plant growth regulators. A further subdivision has been made classifying them according to their chemical composition, wherever possible. The pesticides included in the classification are those listed in the 'Estimated Demand of Pesticides in Fifth Plan'.[1] The description of physical conditions of all pesticides is in accordance with the formulations which are being used and/or are likely to be used in the country.[2] Regarding grades, all the chemicals have been graded on the basis of their toxicity as given in Table 49.16.

TABLE 49·16

Grading Pesticides on Basis of Toxicity[3]

Classification of the pesticides	Medium lethal dose (mg) by the oral route (acute toxicity LD 50 mg/kg body weight of test animals).	Medium lethal dose (mg) by the dermal route (dermal toxicity LD 50 mg/kg body weight of test animals).
1. extremely toxic	1—50	1—200
2. highly toxic	51—500	201—2000
3. moderately toxic	501—5000	2001—20000
4. slightly toxic	More than 5000	More than 20000

The LD50 values of all the pesticides graded have been based on 'Acute Toxicity Data for Pesticides'.[1] For values of chemicals not

1. Fifth Five Year Plan 1974-79. Report of the Task Force IV on Pesticides. Ministry of Petroleum & Chemicals, Government of India.
2. Directorate of Plant Protection. Quarantine & Storage. Ministry of Agriculture, Government of India.
3. Insecticides Rules. 1971.
4. World Review of Peest Control 1970, Vol. 9 No. 3.

mentioned in the World Review, 'Farm Chemicals Handbook'[1] and 'Pesticides Manual'[2] have been consulted. The common names of pesticides/chemicals, together with their chemical names and other trade names are given in Appendix 49.36 for ready reference.

49.10.2 Various categories of chemicals belonging to organic chlorinated compounds, organic phosphatic esters, carbamates and related groups of toxic chemicals are being used extensively in agriculture, food production, silviculture and public health. The spectacular lethal action of these chemicals against insect pests and diseases has encouraged their use throughout the world. In view of the increased emphasis on food production, application of these substances has been on the increase. Unfortunately, pesticides are mostly poisonous and hence of utmost concern in regard to pesticide use are their toxic residues. Hazards associated with the use of pesticides manifest in chronic or acute toxicity in man. Probably chronic toxicity of pesticides involves the entire population while acute toxicity affects only those who are involved in the trade, manufacture, formulation and application of pesticides.

49.10.3 The problem of health hazards of pesticides has become quite significant during the last few years due to (a) increase in the quantities of pesticides consumed; (b) increase in the number of chemicals employed as pesticides; (c) increase in the number of pests against which pesticides are used; (d) conditions and environments under which they are applied; (e) introduction of newer and often more toxic chemicals for use in public health and agriculture; and (f) accessibility of pesticides to unskilled people. The problem relating to the human health and the conservation of wild life arises in general due to four factors, namely, (a) occupational exposure, (b) habituational exposure, (c) accidental exposure, and (d) food contamination. These factors are inadvertently associated with the extended application of pesticides in food production and conservation of resources. Among pesticides, the insecticides have been particularly causing concern with regard to their residual toxicity. Out these, the residual toxicity of DDT, BHC, aldrin, dieldrin, endrin, chlordane, methoxychlor, toxaphene, etc. is known to be highly persistent. The report on the fatal and severe poisoning due to folidol E 605 (containing parathion as active ingredient) has given rise to awareness of the hazards associated with the use of insecticides. Cases of acute poisoning due to several other insecticides have been reported from various parts of the country. Contamination by endrin and related insecticides of water sources has

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1. Farm Chemicals Handbook. 1971. Meister Publishing Co., Ohio.

2. Martin. H. Pesticides Manual. 1968. British Crop Protection Council.

resulted in the death of fish. However, accidental dangers are not so frequent and are often preventible through proper education and precautionary measures. They should not, therefore, be set against the use of pesticides. Apart from acute and subacute toxicity, pesticide operators and consumers of contaminated foods are exposed to the cumulative or chronic toxicity of pesticides. Probably, more significant from the point of view of national health is the danger of consuming minute quantities of residues of pesticides along with foodstuffs over a long period. The unfortunate tendency to consider a chemical poisonous only when it kills quickly is far too widespread. This has led to a situation where insecticides like DDT, BHC, aldrin, dieldrin, endrin, parathion, diazinon, etc. have been used with much less discretion than they deserve.

49.10.4 The residue problems on food have been investigated by several workers. The reports about small quantities of DDT in human body fat with no known direct exposure to DDT raise the question of these compounds being ingested with the normal food. DDT and other insecticide residues have been reported in various foods, milk products and other animal products. There is a need to make a careful survey of the organochlorine insecticide burden in the body fat. Studies on residue tolerances have been made adopting data from FAO/WHO Pesticides Committee, RAO/WHO Food Standards Programme and Codex Alimentarius Committee. Some of the data are shown in Table 49.17. They are under constant scrutiny and liable

TABLE 49·17

Maximum daily Intake and Tolerance Limits of Storage Chemicals and Fumigants

Compounds	Maximum daily intake mg/kg body weight	Tolerance limit (ppm)
bromide (inorganic from fumigants)	1	50
dichlorvos.	0·004	2
hydrogen cyanide	0·05	75 raw cereals flour
lindane	0·0125	0·5
BHC	..	0·01—0·05
malathion	0·02	8 raw cereals 2 flour
phosphamidon	0·001	0·1
pyrethrins	0·04	3
carbaryl	..	2·5 (rice)
aldrin and dieldrin	..	0·01—0·05 (rice)
heptachlor	..	0·02

to modification as more reliable data become available. Tolerance limits for all pesticides used in the country should be ascertained and also those of 'Acceptable Daily Intake' and residue tolerance of different pesticides under Indian conditions. A review[1] of the work done in India on pesticide residues mentions studies made on the monitoring of pesticide residues in food, human tissues and the environment; dissipation of pesticides on crops/agricultural commodities, effect of processing on the removal of pesticide residues; and development of methodology in pesticide residue analysis. The information on the monitoring of pesticide residues in foodstuffs, though meagre, suggests the possibility that gross contamination could occur. Therefore, there is an urgent need to monitor, especially in areas of intensive use of pesticides, foodstuffs for pesticide residues, which should include, besides foodgrains, vegetables, fruits, milk, meat, oils, fats and animal feeds, waters from rivers, fish ponds, lakes, wells and canals.

49.10.5 Most of the pesticide residue surveys have utilised one analytical procedure, *viz.*, either colorimetric method or thin layer chromatography or gas liquid chromatography. The need for using multiple analytical procedures to confirm the identity of the components is necessary. Facilities for more sophisticated techniques like infrared, ultraviolet, and mass spectrometry should be made available. The need is urgent for a systematic survey and monitoring of foodstuffs for pesticide residues using standard procedures. Studies on the degradation of pesticides under good agricultural practices have been made only at a few places in the country. It is known that the degradation of pesticides is influenced significantly by climatic factors. India is a vast country with diverse climate and it is, therefore, necessary that facilities for such studies are provided and developed at a number of locations. Further, studies so far made on this aspect have been restricted to the estimation of the parent compound. Most of the pesticides undergo change after application to the soil, crops or livestock and some of the metabolites may be even more toxic than the parent compound. The potential toxicity of the treated food can only be known if the nature and extent of the terminal residues are studied in detail. In order to study the terminal residues, facilities of tracer techniques, biochemical methods and modern analytical tools need to be developed.

49.10.6 New pesticides are being rapidly developed and introduced for crop protection. These compounds must be tested and examined from various angles including their effect on human health and

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[1]. Bindra, O.S. and R.L. Kalra, 1973. A review of work done in India on Pesticide Residues. In 'Progress and Problems in Pesticide-Residue Analysis', a joint publication of the Punjab Agricultural University and ICAR. pp. 1—44.

on domestic animals before permitting wide scale application. Studies on pesticides other than insecticides have been rather few. There is need for work on fungicides and herbicides. Besides, data on the residues of various fumigants are inadequate. Information on the compounds formed as a result of fumigation of foodstuffs and their toxicity is lacking.

49.10.7 Insecticides are generally applied along with other chemicals *e.g.*, fertilisers, herbicides and growth regulators. Also, often a number of insecticides and fungicides are applied to a given crop. Interactions between the different insecticides and of other chemicals could occur which might modify the degradation and persistence of pesticides. The nature and extent of such interactions need to be studied.

49.10.8 Recognising the upward consumption of pesticides in the country it is necessary to gradually discontinue the highly toxic ones now in use, which have no industrial base in the country, and to find out more suitable and safer substitutes. Also, research and development of less hazardous and superior formulations have to be encouraged and emphasis should be laid on the development of indigenous knowhow of manufacturing pesticide chemicals from indigenous sources. It has been noticed that there are different plant protection schedules prevalent in the country. These schedules are to be re-examined from the point of view of pesticide residues.

49.10.9 The States have mentioned that cultivators have become aware of the hazards of pesticides. This awareness seems to be related to application rather than the residues left in food, fodder, etc. and contamination of water in ponds, rivers and canals. The awareness of benefits of pesticides has sometimes led to indiscriminate and intensive use of them for quick results and gains. It seems necessary that through extensive mass communication media, not only the dangers of acute toxicity but also of chronic toxicity due to ingestion of contaminated food etc. should be publicised.

Pesticides and Soil Microorganisms

49.10.10 The increased consumption of pesticides in agriculture has aroused justifiable concern about their probable deleterious influence directly on soil microorganisms and indirectly on soil fertility. Pesticides which are highly potent are applied to soil together with various adjuvants, synergist, carriers, diluents and solvents for control of insect pests, weeds, nematodes and plant pathogenic fungi. A practical difficulty may arise in trying to distinguish between the effects, if any, of these different kinds of chemicals on soil microorga-

nisms and soil fertility. BHC, DDT, endrin, aldrin, toxaphene and parathion do not appear to disturb microbial activities of soil if used in recommended doses. Of these, BHC and DDT reduce mould counts in soils without affecting the bacterial population. Chlorinated hydrocarbons, in general, are not toxic to ammonifying bacteria. Aldrin, dieldrin and chlordane are more toxic to nitrifying bacteria than BHC, DDT, endrin and methoxychlor. However, the gain in other ways achieved by using pesticides outweighs the small adverse effects, if at all, on microorganisms. Fungicides and fumigants do affect differently commonly occurring bacteria, fungi and unicellular algae. Vapam, for example, decreases the growth of all other microbes except actinomycetes whose activity is rather enhanced by vapam.

49.10.11 The reverse effect, namely, that of microorganisms on pesticides, has been more thoroughly studied, because of the danger of toxic residues. Thus, some of the herbicides are relatively quickly decomposed in soil by microbes, whereas chlorinated hydrocabons have, in general, a long persistence in soil. So long as they do not contaminate the water by leaching from the soil and are not directly absorbed by plants, the danger can be minimised. However, in view of their persistence the use of chlorinated hydrocarbons has been restricted, and it is likely that they would cease to be used in the long run. Recently, some biodegradable DDT—like compounds, *e.g.* alphatrichloromethyl benzylanilines and alphatrichloromethyl benzylphenylether have been synthesised, which have aroused fresh interest in favour of this group of highly effective insecticides.

Integrated Pest Control

49.10.12 Even though more and more specific chemicals are being introduced for plant protection, the evidence is growing that chemical treatment alone may create unfavourable conditions. This is particularly so if broad spectrum chemicals are used over a long period. Chemicals while killing a particular pest or a group of pests may destroy natural enemies of pests, and thereby aggravate the pest situation. Because of the hazards of pollution of environment and loss of ecological balance and consequent dangers to healthy life, there is a tendency in many developed countries to restrict use of chemicals to the minimum. The integrated pest control strategy which ensures this, aims at optimisation of the natural controlling factors. For instance, adverse weather conditions for pests and favourable conditions for natural enemies of pests are created. Control measures are made to coincide with the most vul-

nerable stage of growth of pests. In addition, pest resistant crops, mechanical means, biological methods and pathogens such as viruses are expeditiously employed in suitable combinations. The potentialities of the viruses in fighting plant diseases are enormous but have not yet been touched except at the fringe. Such viruses can be much more specific than insecticides, and at the same time would not disturb the environment, because of their easy biodegradability. But they must be cleared to be safe for human being. Integrated pest control requires adequate knowledge of ecology and biology to guide it, whereas the chemical method is effective, sure and easy to apply. These favourable characteristics of chemical plant control methods have encouraged their greater spread and adoption in spite of the attended disadvantages. Highly selective chemicals which are normally required to be used in small doses are the only answer, but their cost of production, testing and marketing are usually so prohibitive that only few chemical industries find interest in them. Moreover, rapid obsolescence of chemicals acts as a disincentive. That is why broad spectrum chemicals are still in vogue, which are generally used in large doses and thereby become health hazards. In the integrated control method, the ecological selectivity of such chemicals may be taken advantage of to make discriminative use of them to develop effective, economical and as far as possible ecologically sound control methods. For this purpose, knowledge of ecology, biology and behaviour of pests and their natural enemies, crops and crop complex, and characteristics properties of chemicals is required. More important is the need of experienced crop protection specialists. In order to minimise pollution hazards, more and more nonpesticidal control methods have to be devised and suitably integrated with chemical methods. Some schedules of integrated pest control measures for a number of crops were formulated by Pradhan[1] on the basis of the then available information. The control of locusts is an example of large scale application of the integrated method of pest control.

Storage Pesticides

49.10.13 Stored grains may be damaged by one or more of the following causes: (a) dampness, (b) temperature variation, (c) rats, and (d) insects, mites and microorganisms. The first two factors can be controlled by storing grains in special structures which allow moisture content of dried grains to remain at or below the minimum limit (about 8 per cent to prevent most insect infestations).

1. Pradhan S. 1970 Agricultural Yearbook. ICAR. Chapter 6 on Plant Protection.

The walls of containers may be made of materials having low thermal conductivity in order to prevent temperature variations. Airtight structures reduce insect infestation by limiting oxygen availability. The oxygen requirement of pests for survival varies considerably depending on the insect species and stage of their growth. Complete absence of oxygen is, however, not necessary. The damage caused by rats may be prevented, if done on a compaign basis, by storing grains in ratproof godowns provided with rat poisons and traps. These aspects are discussed in greater details in Chapter 56 on Marketing Transport and Storage. By controlling moistures and oxygen contents and temperature variations, storage structures can be suitably made to prevent pest infestation to a considerable extent, and in many cases no insecticide would be necessary. Fumigation of grains and storage structures or godowns with chemicals like ethylene dibromide, ethylene dichloride, methyl bromide, ED/CT mixtures, etc. is one of the safest ways of disinfecting grains provided the proper choice of fumigant is made. But the handling of fumigrants, some of which are skin toxic and require special appliances, may be beyond the capacity of ordinary farmers. Potent pesticides like DDT, BHC and malathion are commonly used but because of their persistence and toxicity, the use, if at all, should be confined to the preservation of seeds alone. The risk involved in case seeds are used for human and animal consumption is so great that suitable precautionary measures should be taken to see that the pesticides are rendered nontoxic by the time the grain is ready for consumption, or else, the consumers should be educated how to prevent ingestion of toxic ingredients of pesticides. Of the nonchemical methods and control of storage pests by using the sterile male techniques has shown great promise and deserves to be fully explored.

11 QUALITY CONTROL OF PESTICIDES

Complaints about Quality

49.11.1 We have received complaints during discussions with different States that in a number of cases pesticides received by the farmers are of substandard quality and appear to be adulterated. The very purpose of increasing production to attain self sufficiency would be defeated if the farmers do not get the expected benefits by using substandard and adulterated pesticides. An analysis of the information obtained indicate that all the States have recorded complaints about sale of substandard/adulterated pesticides. Bihar has received

some serious complaints with regard to substandard quality of aldrin, BHC, and endrin, while in Karnataka the complaints are against quality of carbaryl 10% D* (dust) DDT 50% WP, malathion 5% D, and Zineb 78% WP. Maharashtra reported adulteration of pesticides with weedicides. There are generally no complaints of adulteration with regard to other pesticides. Those chemicals which have captured the goodwill of farmers and are in good demand are commonly adulterated by unscrupulous pesticide dealers. It is the practice with farmers to go in for these pesticides with which they become familiar through trade names, and about whose efficacy they have been convinced through demonstrations, even though the same product could be had under trade names of their manufacturers/formulators. The complaints generally relate to locally formulated and imported pesticides. Another reason may be that some of the pesticides differ a great deal in their keeping quality, as a result of which both the physical and chemical properties deteriorate. Moreover, during a pest season they are more quickly consumed to allow any laboratory analysis and consequent check up. Sometimes, it is the long period of storage of these pesticides, which offers opportunities to the dealers to adulterate the materials at different stages of distribution. Some of the states have reported that a greater part of the adulteration takes place most likely at the retailes' rather than at the wholesalers' end.

Factors Determining Quality Deterioration

49.11.2 There is no price control on pesticides. Government agencies buy pesticides from manufacturers/formulators at competitive rates through tender, whereas private dealers buy at normal prevailing market rates as fixed by the pesticides industry from time to time. This causes a difference in the selling price. But none of the States have made any complaints regarding adulteration of pesticides due to the difference in market price and official price. Probably this has neither come to their notice nor been reported. But the price difference may tempt unscrupulous dealers to indulge in adulteration, particularly when the demand is more than the supply.

49.11.3 The longer the period of storage, the greater the likelihood of deterioration in quality. Karnataka has observed that in the case of concentrated pesticides the effect of storage and packing is less than in diluted pesticides. Formulated pesticides have a built-in shelf-life of one year. If these are stored longer than their shelf-life there

*For abbreviations reference may be made to Appendix 49·35

would be some deterioration in quality. No systematic studies have so far been undertaken to determine the shelf-life of different pesticides. The ISI has yet to take up such a study. Some study has been done in the chemical laboratory at Bombay of the Directorate of PPQ &S.

49.11.4 Bad storage conditions, leaky godowns, damage of gunny bags and containers, improper packing, etc. result in deterioration of the quality through change in physical status and loss of soluble constituents and other characteristics. No work on keeping quality of pesticides in storage has been done. It, therefore, becomes necessary that steps are taken, as part of pesticide promotion, to introduce effective methods for the storage of pesticides. The Insecticides Act (1968) has specified conditions for the storage of pesticides

Arrangements for Pesticide Analysis

49.11.5 It appears that there is no uniformity in the procedure adopted by different States for drawing and analysis of pesticide samples. For the purpose of drawing samples some of the States have variously declared Agricultural Inspectors, Deputy Directors of Agriculture, Assistant Directors of Agriculture, and other Agricultural field officers responsible for the collection and despatch of pesticide samples. ISI Inspectors also collect samples for analysis. The samples are generally drawn at the retailers' end and sent to chemists at central laboratories like the chemical laboratories of the PPQ&S at Bombay and Calcutta, ISI laboratory, Delhi, and CFTRI, Mysore. Most of the States do not have separate laboratories for pesticide analysis. Karnataka is making arrangements for establishing a laboratory for analysis of plant protection chemicals at Bangalore under the control of the Department of Agriculture. The number of laboratories for analysis of pesticides is very limited. A few States have suggested that methods and facilities for systematic sampling and analysis be made at the State level. Some others have suggested a separate organisation to be set up at the State level for the enforcement of the Insecticides Act. Facilities at the command of the Central Government are very limited and much needs to be done. Improvements can be achieved by acting according to the provisions of Insecticides Act.

49.11.6 With a view to popularising and expanding the use of pesticides, the Government of India, until recently, have been following a policy of issuing pesticide formulation licences to small scale industries. It is not known whether these small units have facilities for formulating products according to the specified processes and possess required equipment and qualified staff for rigid quality control. The

Insecticide Inspectors provided under the Insecticides Act should have these units under their jurisdiction.

49.11.7 The large producers of pesticides have facilities for analysing their products so that the desired quality of the final products is ensured. Moreover, steps have been taken to make bags containing pesticide dusts tamperproof by machine stitching. But all do not have metal seals. Liquid formulations and wettable powders are packed in metal containers and glass bottles, but all of them are not pilfer proof. The ISI has prepared standards for 114 formulated pesticides. Only certain pesticides do have ISI marking. None of the States except Karnataka has made any complaints. Karnataka has reported adulteration at the factory level. No suggestions for quality control at manufacturers' level have been put forward by the States. It is felt that all bags containing formulated pesticide dusts should be of uniform standards and machine stitched with metal seals. Other formulated products in metal containers and glass bottles should be made pilfer proof. Moreover, batch numbers should be printed or stamped on the labels of containers or bags as the case may be. This would facilitate sampling by Insecticide Inspectors and the Insecticide Analysts to check the quality of pesticides under the provisions of the Insecticides Act. It is also necessary that the ISI should address itself as quickly as possible to establish standard for pesticides wherever such standards are not available. The manufacturers should be induced in their own interest to come under the ISI Quality Marking System.

49.11.8 Fertiliser Pesticide mixtures are not in vogue as yet and so far are not popular. In the event of future extension along this line, measures for quality control should be thought of in advance. The responsibility of the ISI in this area of activity was referred to in our Interim Report on Fertiliser Distribution (also see paragraph 49.9.6 of this chapter).

49.11.9 The checking of quality at the distribution level is a difficult task. The Insecticides Act has made provisions for Insecticide Inspectors to sample pesticides under their jurisdictions. But it is necessary for the manufacturers and the State departments to expand their activities by drawing samples at intervals. It is necessary for the Insecticide Inspectors and the State departments to fix a target of sampling. At present, there are a few laboratories for analysing pesticides and their capacity is limited. The number of samples to be drawn and analysed would be determined by the number of Insecticide Inspectors to be engaged in the collection and despatch of samples to the laboratories. The number of samples so drawn is also dependent on the batch of manufacture which constitute a lot

and the number of containers chosen from individual lots. The period of sampling should coincide as far as possible with the storage time of pesticides at the consumers' end. Moreover, the time of sampling for enforcing quality control should be such as to be most effective. The best time for sampling and analysis would be before the two major cropping seasons, *kharif* and *rabi*, when advance build up of stocks is in full swing. At that time, the results of analyses can be used to enforce quality control. However, the periods of sampling would vary with the cropping season in different agroclimatic regions. In addition, random surprise checks should be carried out regularly by the Insecticide Inspectors from the godowns of manufacturers, wholesalers and retailers to check adulteration and to prevent tampering with quality.

49.11.10 The Insecticides Act has made provisions for the setting up of a Central Insecticides Laboratory which is yet to be established. Besides the Central Laboratory, the Ministry of Agriculture and Irrigation has suggested the need for Regional Laboratories. But it would be preferable to have one properly equipped pesticide analysis laboratory in each State, or in certain regions for a group of States, depending on the quantity consumed, so as to enable the results of analysis of pesticide samples made available within 15 days from the date of drawal of samples.

Methods of Sampling and Analysis

49.11.11 Methods of sampling and analysis need to be standardised and improved upon from time to time based on experience. These methods should be uniform throughout the country and brought within the scope of the Insecticides Act and the Quality Marking System of the ISI. All methods should be subjected to periodical scrutiny for the purpose of incorporating latest modifications and improvements as and when necessary. Although the ISI has standard methods for analysing pesticides, it is necessary to establish a Central Committee of analytical chemists representing the agricultural universities, the ICAR, the State Agricultural Departments, the pesticides industry, the ISI and the National Test House and other quality control laboratories at the natioal level to undertake the task of formulating standard methods of analysis and exercising periodical reviews. Almost all the State Governments have welcomed the constitution of such a Central Committee for the purpose. The Central Laboratory, when established following the provisions made for it in the Insecticides Act, could very well disseminate uptodate information on quality control measures and other necessary information to the State laboratories

The Central laboratory should also have arrangements for training quality control personnel engaged in drawing and analysis of pesticide samples.

Rapid Testing

49.11.12 Any delay in analysing samples is likely to defeat the very purpose for which it is being done. So far there are no quick methods of analysis of pesticides. Considerable effort and attention have to be paid to equip pesticide analysis laboratories with equipment for quickening analysis. Almost all the States have complained about nonavailability of rapid testing techniques and equipment. Quick tests which would stand the requirements of legal proof are still not available. There is, therefore, a need to develop faster analytical procedures. Attention has to be paid to whether mobile soil testing laboratories could be equipped to carry out preliminary pesticide analysis. Samples found substandard may thereafter be subjected to conventional methods so as to take necessary legal action under the Insecticides Act.

49.11.13 Most of the agricultural universities have no facilities for pesticide analysis, but it should be possible for them to set up laboratories and develop methods of analysis which are comparatively simple and quick. It should also be possible for them to impart training to the quality control personnel in methods of drawing and analysing the samples. At present, research work on various aspects of quality control of pesticides is being carried out only at Division of Agricultural Chemicals, IARI, New Delhi. Additional pesticide analysis laboratories which are likely to be set up in future should preferably be located in the campuses of the agricultural universities, so that the latter can assist the laboratories in an advisory capacity.

Adequacy of the Insecticides Act

49.11.14 One of the objectives of the Insecticides Act (1968) is to ensure quality control of pesticides. The Act places restrictions on the sale and distribution of substandard pesticides in the following circumstances:

(i) if the label contains any statements, design or graphic representation relating thereto which is false or misleading in any material particular, or if its package is otherwise deceptive in respect of its contents; or

(ii) if the pesticide is an imitation of, or is sold under the name of, another pesticide; or

(iii) if the label does not contain a warning or caution which may be necessary and sufficient, if complied with, to prevent risk to human beings or animals; or

(iv) if any word, statement or other information required by or under the Act to appear on the label is not displayed thereon in such conspicuous manner as to render it likely to be read and understood by any ordinary individual under customary conditions of purchase and use; or

(v) if the pesticide is not packed or labelled as required by or under the Act; or

(vi) if the pesticide is not registered in the manner required by or under the Act; or

(vii) if the label contains any reference to registration other than the registration number; or

(viii) if the pesticide has a toxicity which is higher than the level prescribed or is mixed or packed with any substance so as to alter its nature or quality or contains any substance which is not included in the registration.

In addition, manufacturers are required to comply with certain packaging conditions of a type approved by the Registration Committee. Any dealer who contravenes the provisions of the Insecticides Act is liable to prosecution and punishment with imprisonment upto 3 years or with fine, or with both. Although the Insecticides Act has been enacted, the provisions and rules are yet to be implemented fully. It is yet to be seen how the Act works before any suggestions could be made. It is, therefore, necessary that the Act be immediately implemented fully in all the States.

Testing and Certifying Authorities

49.11.15 The Insecticides Act has made provisions for Insecticide Analysts and Insecticide Inspectors. The former would analyse pesticides received from the Insecticide Inspectors as to their quality and send reports back to the Inspectors. The Inspectors would then take such legal action as necessary.

Extension Education on Quality

49.11.16 Farmers are the end users of pesticides. They are often deceived by unscrupulous dealers because of their ignorance about quality. While the Insecticides Act is yet to be fully enforced to regulate quality, there cannot be any better substitute than educating the

farmers about the quality of pesticides. Farmers are at present trained at farmers' training centres in the States. In these training programmes, special emphasis should be laid on quality control of pesticides, identification of standard materials and the legal provisions made for apprehending unscrupulous dealers. As of now, the farmers are not aware or are not being made aware of the legal steps to ensure the quality of pesticides. In order to educate the farmers with regard to the existing facilities available for the testing of pesticides and in distinguishing the standard materials from the spurious ones, the use of publicity media, like audiovisual aids, posters, film shows, advertisement in local newspapers, television and radio programmes etc. should be undertaken. The Insecticides Act and the Insecticides Rules should be translated into regional languages and made easily available to the farmers.

49.11.17 The use of pesticides in the country is still far behind the estimated requirement. Some pesticides and their formulations are specific and a particular pesticide and its formulations work satisfactorily only on a particular pest of a particular crop. Such restricted use is not desirable keeping in view the possibility of development of resistance in insects. Moreover, recommending one out of different but equally effective brands of the same pesticide and its formulations would discourage competition. The quality control laboratories should keep a check on quality of various brands and be able to suggest alternative forms of pesticides, such as dusts, wettable powders, emulsifiable concentrates or granules. Most of the pesticides are generally required in small quantities. If, therefore, wherever possible small amounts instead of bulk quantities are made available in tamperproof containers the risk of adulteration may be reduced. This arrangement would at the same time enable even small farmers to buy pesticides which they cannot afford if sold in bulk.

Central Pesticides Release Committee

49.11.18 The Insecticides Board provided by the Insecticides Act, functions, as an advisory body to the Union Ministry of Agriculture and Irrigation, keeping in mind

(i) the risk to human beings or animals involved in the use of pesticides and the safety measures necessary to prevent such risk; and

(ii) the manufacture, sale, storage, transport and distribution of pesticides with a view to ensuring safety to human beings and animals.

The Registration Committee which is already functioning has to register insecticides after scrutinising their formulae and verifying claims made by the importer or the manufacturer as the case may be, as regards their efficacy and safety to human beings and animals. The setting up of a Central Pesticides Release Committee as suggested by some is likely to duplicate the functions of the Insecticides Board and the Registration Committee. Moreover, delegation of the functions of the proposed Committee would prevent enlargement of the functions of the Insecticides Board and the Registration Committee. Most of the States are not in favour of a Central Pesticides Release Committee.

12 PLANT PROTECTION SERVICES

49.12.1 The system of distribution of pesticides is becoming more important with their increasing use. The distribution is being handled by various agencies, most important being the State departments, cooperative societies and private traders. The surveys[1] conducted by the Pesticides Association of India (PAI), New Delhi, reveal that farmers buy pesticides more often from private and cooperative societies than Government agencies. The total number of distribution centres run by all these agencies is at present about 32,000[2] which are supposed to cater for more than 600,000 villages, i.e., there is one depot for 19-20 villages. These figures speak of a poor distribution system which needs to be geared up.

49.12.2 From Table 49.18 it may be observed that most of the States except Gujarat and Orissa are doing distribution of pesticides through State Agriculture Department or agro-industries corporation which is a Government undertaking. In Gujarat, a subsidy is given to a cooperative society for opening sale points in the rural areas for the distribution of pesticides with the hope that it would stabilise the price of pesticides. In Maharashtra, Andhra Pradesh, West Bengal, Rajasthan and Haryana, the distribution is being done by both the Government and cooperative agencies. Andhra Pradesh distributes pesticides on no-profit-no-loss basis but gives subsidy in the centrally sponsored schemes on cotton, oilseeds, tobacco and mesta. Marketing federations are involved in the distribution system in Karnataka, Jammu & Kashmir and Orissa. In Orissa, the federation is the main agency

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1. Pesticides Market Studies (1972), Ahmednagar District, Maharashtra State. Vol. VII (Resurvey.) Pesticides Association of India. New Delhi. p. 121.
2. All-India Plant Protection Conference (1974), Directorate of Plant Protection. Quarantine and Storage, New Delhi. p.3.

TABLE 49·18

Distribution Agencies of Pesticides in Different States[1]

State	Agro-industries/ agriculture department	Cooperative societies	Marketing federation	Private traders
Andhra Pradesh	†	†		†
Assam	†			†
Bihar	†			
Gujarat		†		
Haryana	†	†		†
Himachal Pradesh	†			
Jammu & Kashmir	†		†	
Karnataka	†		†	†
Maharashtra	†	†		†
Manipur	†			
Nagaland	†			
Orissa			†	†
Rajasthan	†	†		†
Tripura	†			
Uttar Pradesh	†			†
West Bengal	†	†		†

1. Prepared from States' replies to our questionnaire.
† Distribution of pesticides done.

looking after distribution while in Karnataka and Jammu & Kashmir, the federation is working hand in hand with the State departments. Private traders are active in Assam, Karnataka, Orissa, Maharashtra, Andhra Pradesh, West Bengal, Uttar Pradesh, Rajasthan and Haryana along with other agencies.

49.12.3 State departments have been doing the distribution work through their plant protection stores, which are mostly located at the district level. In some of the States those facilities are extended at

the subdivisional or tehsil level. Consequent upon the withdrawal of subsidy, State departments are confining themselves to research, co-ordination, extension and field trials, leaving the distribution work to cooperative societies and private agencies. Private agencies are at present handling nearly 60 per cent of the work. The survey conducted by the Pesticides Association of India (PAI) in Ahmednagar (Maharashtra) reveals that the main agencies from which pesticides were purchased by farmers during 1968-70 were cooperative, private and government agencies. But cooperative and private agencies competed for the first place in both these years. Bearing in mind that the co-operatives need support till they can stand on their own, the State departments should render necessary assistance and continue distribution of pesticides so long as the cooperative societies become self-sufficient in the business. State departments should also keep emergency stock of popularly consumed pesticides. A recent decision of the Government of India to entrust the State departments with 50 per cent technical grade material of commonly used ten pesticides would help the States maintain the supply line.

TABLE 49.19

Position of Supply of Pesticides*

States	Replies with regard to timely supply and suggestions, if any
1	2
Andhra Pradesh	not getting timely supply.
Assam	not getting timely supply, substitutes are recommended on shortage of particular brand.
Bihar	farmers are not getting timely supply of pesticides in adequate quantity.
Gujarat	flow and supply are satisfactory except when farmers insist on particular brand.
Haryana	farmers are getting adequate supply timely
Himachal Pradesh	getting timely supply.
Jammu & Kashmir	not getting timely supply due to smaller number of depots situated at distances.
Karnataka	indigenous chemicals are available, but not so in case of imported pesticides.
Maharashtra	not satisfactory, advise increase of local production and import, and rationalisation of the industry to enable distribution through cooperative/government agencies.

TABLE 49.19 (Contd)

1	2
Manipur	getting timely supply.
Nagaland	not getting timely supply.
Orissa	farmers are getting timely supply, and are advised substitutes in case of shortage of particular brands.
Rajasthan	government tries to maintain supply, but sometimes difficulties arise due to natural calamities.
Tripura	getting timely supply.
Uttar Pradesh	getting timely supply.
West Bengal	getting timely supply.

*Prepared from States' replies to our questionnaire.

Cooperative agencies being new in the field should have their staff properly trained by State departments. Private agencies try to concentrate only in towns and areas accessible by train. They should be encouraged to work hand in hand with cooperative agencies and extend their field of activities to backward areas.

Timely Supply

49.12.4 Adequate and timely supply of pesticides to the farmers is vital for getting maximum benefit from the use of chemicals. From Table 49.19 it may be seen that cultivators in Assam, Maharashtra, Andhra Pradesh, Rajasthan, Jammu & Kashmir, Bihar and Nagaland are not getting adequate and timely supply of pesticides, while those of Karnataka, Tripura, Gujarat, Orissa, Manipur, Haryana, West Bengal, Uttar Pradesh and Himachal Pradesh are getting supply of pesticides in time except only when farmers insist on a particular brand and would not accept a substitute. There are some difficulties in getting the supply of imported pesticides like carbaryl, endosulfan and endrin. The remedial measures to correct such imbalances as occur between demand and supply seem to be (a) to increase local production; (b) to import pesticides well in advance; and (c) to streamline distribution system. In addition, State departments should maintain emergency stock to guard against natural calamities and unforeseen situations. All stocks lying with various distributing agencies should be occasionally checked. Difficulties arising out of untimely financial allocations could be overcome by taking steps well in advance.

Sale Points

49.12.5 The PAI surveys[1] carried out in Maharashtra, Gujarat, Bihar and Himachal Pradesh have shown that cultivators have to travel long distances to obtain their supplies of pesticides. It has also been observed that distribution centres are generally opened in demand areas. For instance, in demand areas like Phaltan or Baramati in Maharashtra, there are 20-30 stockists while in the remaining parts of the district only one or two. Again, places which are easily accessible by railway or road are preferred as new distribution centres by private traders. These drawbacks may be remedied if, while issuing licences, equal opportunities are given to all categories of farmers, especially those of the smaller ones. It is further to be seen that the sale points are not dispersed too widely. Distributors may approach young farmers for opening sale depots in villages offering suitable commission on the sale of pesticides. The farmers' service society, recommended by us in our Interim Report on Credit Services for Small and Marginal Farmers and Agricultural Labourers, may be entrusted with the task of running input depots including those of pesticides, so that they become available in time to the members of the society.

49.12.6 Pesticides are mainly transported by railway and road. Road transport is considered safer and more efficient but is more costly than railway transport. The chief bottlenecks with railways are shortage of wagons and the low priority given to pesticide movement as compared to fertilisers. Further, transport problems arise due to long distances of sale points from user villages as mentioned above. We recommend that the same priority as given to fertilisers should be extended to pesticides in the matter of allotment of railway wagons and their movement. Pesticides should be transported in closed wagon so that damages due to bad handling are avoided.

Storage

49.12.7 Most of the private traders use, for the sake of economy, storage places which are close to railway track or are easily accessible by road. State Agriculture Departments store chemicals usually in one location for the whole district but in some places they have stores for the taluk or the subdivision. These stores also act as sale

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[1]. Pesticides Market Studies 1972 Vols. VII, VIII, IX & X respectively. Pesticides Association of India.

points. Cooperative agencies hire either private godowns or warehouses for keeping pesticides. Some of the storage placcs are far from satisfactory and chemicals stored in them are likely to deteriorate in quality. The godowns and storage facilities available with agencies like the Fertilizer Corporation of India should be given on a priority basis for pesticide storage. There should be proper facilities of storing at the port and railway terminals in order to minimise the loss due to adverse weather condition especially during the monsoon.

Custom Service

49.12.8 From an analysis of replies received from State Governments it is observed that custom service for spraying pesticides is either absent or just a beginning has been made in some of the States, e.g., Rajasthan, Haryana and West Bengal. Private parties do not seem to find it remunerative, nor are farmers, who like to remain individualistic, accommodating enough for custom service, even though the Government is willing to give concessions in the form of loan and equipment. Custom service, if it becomes acceptable, would be a good avenue of employment for agricultural graduates. The idea of custom service is very relevant in case of epidemics.

Subsidy

49.12.9 From the information given in Table 49.20, it would be seen that almost all the States except Orissa, West Bengal, Uttar Pradesh and Bihar give subsidy for the purchase of pesticides. Rajasthan gives subsidy of 50 per cent in time of epidemics. The percentage of subsidy generally ranges from 25 to 50 per cent, except in Nagaland where it is 100 per cent, and in Himachal Pradesh, where 100 per cent subsidy is given for transportation from railhead to distribution centres. Subsidy, whatever be its form and amount, was meant to popularise use of pesticides. Now that farmers are conscious of the benefits of plant protection, most of the States are in favour of discontinuing subsidy for purchase of pesticides. We are in favour of discontinuing subsidy to big farmers, but would recommend that certain amount of subsidy may be given to the small and marginal farmers. We further recommend that subsidy may be given (a) for transportation charges of pesticides from rail heads to distribution points for stabilising prices; (b) for aerial spray; (c) for appliances; (d) for spraying pesticides in epidemic areas; and (e) for opening more sale points in backward areas.

TABLE 49.20

Subsidy Given by States for Purchase of Pesticides.

State	Percentage subsidy
Andhra Pradesh	25 to 50
Assam	50
Bihar	none
Gujarat	25 limited to Rs. 50 per cultivator
Haryana	25
Himachal Pradesh	100 subsidy on transportation of pesticide from railway head to distribution centre
Jammu & Kashmir	100 for cutworm maize borer from 1970-73; 25-50 in 1974-75.
Karnataka	25 to 50
Maharashtra	25 and more.
Manipur	50
Nagaland	100
Orissa	none
Rajasthan	50 (in case of epidemics only).
Tripura	50
Uttar Pradesh	none, except in some special cases
West Bengal	none

Promotional Work

49.12.10 Subsidies recommended above are likely to act in some way as incentive and help promotion of pesticide use. Credit facility available for inputs is another form of incentive. Other promotional efforts in the form of plant protection demonstrations, mass meetings, distribution of popular literature, pamphlets, booklets, charts, guides, radio broadcasts and seminars etc. are made by both Government and panchayat agencies with some participation of the manufacturers. Most of the States have reported that the contribution of cooperative societies towards promotion of pesticide use is negligible. Private agencies are doing promotional work only in a few pockets. It is observed that the present state of promotional efforts made by State Governments is not satisfactory. It is suggested that a part of the savings accruing from withdrawal of subsidy should be utilised for promotional activities, such as the training of farmers, demonstration in farmer's fields, custom service, opening suitably located sale points, provision of technical guidance regarding use of pesticides and their harmful effects, besides usual extension services.

Plant Protection Organisations

49.12.11 Plant protection work is mainly handled by (a) the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) of the Union Ministry of Agriculture and Irrigation, and (b) the Agriculture Departments in the States. The DPPQ&S is headed by the Plant Protection Adviser to the Government of India, who also functions as the Director, Locust Control. He is assisted in his work by a Deputy Director, Assistant Directors and other officers and different categories of technical and administrative personnel. The main functions of the Directorate consist of (a) locust survey, intelligence, investigation and control; (b) operation of a plant quarantine service; (c) assistance to States, Union Territories and others with technical advice, personnel, pesticides and equipment for fighting insect pests and diseases; (d) organisation of regional surveys, insect pest and disease control campaigns and training programmes for officials; (e) tests and trials of pesticides and development of practical methods and measures for plant protection; (f) aerial service against insect pests and diseases; (g) advice and assistance regarding the prevention of damage in storage; (h) advice and assistance to the Government of India in meeting all international and domestic commitments pertaining to plant protection; (i) advice and assistance to the Central and State Government on the procurement, manufacture and formulation of pesticides and application equipment; (j) collection, collation and dissemination of information about insect pests, plant diseases and plant protection measures, methods, techniques, pesticides and appliances.

49.12.12 It is seen that the DPPQ&S is involved in multifarious activities and responsibilities, all of which are of highly technical nature. Responsibilities and functions are efficiently and more satisfactorily carried out if commensurate powers of taking decisions and implementing them are vested in the officers concerned. In this context we are of the view that the status of the DPPQ&S should be upgraded so that the Plant Protection Adviser, like similar other Advisers in the Government of India, enjoys the status of a Joint Secretary.

Setup in States

49.12.13 Most of the States have separate plant protection organisations under the Agriculture Departments. But, as seen from States' replies to our questionnaire, there is no uniformity in the staff pattern of different states. For example, in Tripura, Rajasthan and Uttar

Pradesh, plant protection work at the State level is looked after by an officer of the rank of Deputy Director of Agriculture. While in Karnataka, Andhra Pradesh, Himachal Pradesh, Maharashtra and Bihar, there is a Plant Protection Officer in charge of plant protection work. These officers are further assisted by a number of Plant Protection Officers/Assistant Plant Protection Officers at the divisional or district level to supervise the plant protection activities. The Plant Protection Officers/Assistant Plant Protection Officers are of the rank of Class II gazetted and are assisted by the subject matter specialists/ Plant Protection Assistants/Plant Protection Inspectors/Plant Protection Supervisors. At the block level plant protection work is looked after by the officers with the help of village level workers. It is, therefore, suggested that for the sake of uniformity in the administrative setup and the importance of plant protection work the status of the Plant Protection Officer at the State level should be that of Deputy Director of Agriculture (Plant Protection). In our Interim Report on Fertiliser Distribution and officer of the rank of a Joint Director has been recommended to be in charge of supervising, distributing and regulating use and quality of all inputs, such as fertilisers, plant protection chemicals, seeds, etc. The Joint Director having specialisation in any of the inputs would have immediately below him a number of input specialists having the status of a Deputy Director. At the divisional, district and block headquarters, plant protection work may be looked after by Plant Protection Specialists of Class I and Class II status and graduate specialists respectively.

13 SUMMARY OF RECOMMENDATIONS

49.13.1 The following are the important recommendations made in this chapter.

1. Most of the crops are able to recoup from injuries by pest attack incurred early in their growth or away from the critical stage. Such critical stage for each variety of crop should, therefore, be ascertained by careful experimentation.

(Paragraph 49.3.8)

2. The Institute of Agricultural Research Statistics should examine the available data on various coordinated trials carried out all over India to arrive at an estimate of crop losses by insect pests and diseases. The Institute may design experiments to enable valid estimates to be made of crop losses by insect pests and diseases.

(Paragraph 49.3.9)

3. Research work and field study for the estimation of crop loss under different agroclimatic regions and pest situations should be continued at least for 3-5 years for the purpose of verification. Wherever possible, laboratory work and field testing may run simultaneously to gain time. Crop loss estimates should preferably be expressed on a uniform basis.

(Paragraphs 49.3.10 and 49.3.11)

4. A close coordination of research work done by different research institutions, agricultural universities and State Departments of Agriculture would be highly desirable. It may be opportune to associate the pesticide industry at a consultative level.

(Paragraph 49.3.11)

5. All future studies on plant protection chemicals should preferably be correlated with the losses caused by various pests under different conditions and in different regions.

(Paragraph 49.4.5)

6. With changing cropping patterns, pest surveillance should become an integral part of crop protection. New crop introductions which are likely to bring hitherto unknown pests should be watched cautiously.

(Paragraph 49.5.1)

7. Pest surveillance programme should be continued throughout the year beyond the wheat growing season, particularly in the hills, for getting a clearer understanding of the inoculum potential, perpetuation, survival and movement of rust spores.

(Paragraph 49.5.7)

8. The *ad hoc* Rice Survey should be placed on a permanent footing to allow it to carry on 'off season' surveys preferably in the endemic areas.

(Paragraph 49.5.8)

9. There is a need for a thorough reexamination of the techniques and procedures of sampling stated in the FAO Manual, 'Plant Pests Diseases Survey Manual for Plant Protection Workers' for the purpose of improving on them.

(Paragraph 49.5.13)

10. Surveillance — Forecasting Plan should specially be concerned with the occurrence of major as well as minor insect pests and diseases and the distribution of species, exact time of occurrence, varieties of crops affected, plant growth stage preferred etc.

(Paragraph 49.5.14)

11. Surveillance project should continually strive to find methods suitable for determining the occurrence of each individual insect pest

and disease. This activity should either be a part of the research work being done or the subject of new research projects.

(Paragraph 49.5.15)

12. A more accurate estimate of the benefit-cost ratio should be obtained by carefully carrying out a large number of field experiments (result demonstrations) which would enable analysis of the data according to crops and treatments.

(Paragraph 49.6.6)

13. The State departments should review their plant protection setup, especially the extension unit, and streamline the organisation for increasing farmers' awareness regarding the magnitude of damage caused by pests and that of plant protection measures needed. It is suggested that the pesticide industry should also undertake intensive efforts to educate farmers.

(Paragraph 49.6.9)

14. States should maintain a complete yearwise record of all the plant protection chemicals actually being consumed according to a uniform system. These data should not only refer to records kept at the Governmental level but should also include those distributed through private and other agencies.

(Paragraph 49.7.7.)

15. In view of the lack of any relation whatsoever between the recommended chemicals in the plant protection schedules and those required and consumed by the States, the present plant protection schedules should be revised immediately, making it obligatory to revise them every two years.

(Paragraph 49.7.18)

16. The State Surveillance agencies should maintain records of cropwise pest problems together with the time and intensity of attack. In the long run this information would be of use not only to assess more exactly the requirement of chemicals but also to plan control operations more systematically.

(Paragraph 49.7.18)

17. The State plant protection units should be reorganised to collect and evaluate data on pest problems, cropwise and seasonwise, and of the pestwise requirement of chemicals. They should accordingly be armed with necessary equipment, machinery, trained personnel and other facilities to fight sudden outbreaks and emergencies.

(Paragraph 49.7.19)

18. Efforts are needed to develop knowhow for the indigenous manufacture of intermediates, active technical pesticides and their formulations.

(Paragraph 49.8.1)

19. Research work on naturally occurring pesticides and on products synthesised from them and having desirable stability should be intensified.

(Paragraph 49.8.13)

20. For introducing fertiliser — pesticide mixtures, studies should be undertaken to find out (a) the conditions for a homogeneous mixture; (b) reactions which affect the efficacy in the mixture of either the plant nutrient or the protection chemicals or of both; and (c) keeping qualities of the mixture in storage.

(Paragraph 49.9.3)

21. A Committee representing the agricultural universities DPPQ&S, ICAR, IARI, ISI and the fertiliser and pesticide industries should thoroughly study the use of fertiliser — pesticide mixtures in relation to the pattern of future consumption of both fertilizers and pesticides, changes in cropping patterns under various agroclimatic conditions, pest complex, and cost of application.

(Paragraph 49.9.6)

22. There is an urgent need to monitor especially in areas of intensive use of pesticide, foodstuffs for pesticides residues, which should include, besides foodgrains, vegetables, fruits and milk, meat, oils, fats and animal feeds, waters from rivers, fish ponds, lakes, wells and canals. Tolerance limits for all pesticides used in the country should be ascertained, and also those of the "Acceptable Daily Intake" and residue tolerance of different pesticides under Indian conditions.

(Paragraph 49.10.4)

23. The need for using multiple analytical procedures to confirm the identity of the components of pesticides residue is necessary. Facilities for more sophisticated techniques like infrared, ultraviolet and mass spectrometry should be made available.

(Paragraph 49.10.5)

24. Facilities for studies on degradation of pesticides and on residues should be provided and developed at a number of locations in the country.

(Paragraph 49.10.5)

25. Recognising the upward consumption of pesticides in the country it is necessary to gradually discontinue the highly toxic ones now in use, which have no industrial base, and to find more suitable and safer substitutes. Also, research on and development of less hazardous and superior formulations have to be encouraged and emphasis should be laid on the development of indigenous knowhow of manufacturing pesticide chemicals from indigenous sources. The

different plant protection schedules should be re-examined from the point of view of pesticide residues.

(Paragraph 49.10.8)

26. For adopting integrated pest control, knowledge of ecology, biology and behaviour of pests and their natural enemies, crops and crops complex, and characteristic properties of chemicals is required. In order to minimise pollution hazards, more and more nonpesticidal control methods have to be devised and suitably integrated with chemical methods.

(Paragraph 49.10.12)

27. Because of their persistence and toxicity, the use, if at all, of DDT, BHC, malathion etc. as storage pesticides should be confined to seeds.

(Paragraph 49.10.13)

28. All bags containing formulated dusts should be of uniform standards and machine-stitched with metal seals. Other formulated products in metal containers and glass bottles should be made pilfer-proof.

(Paragraph 49.11.7)

29. The Indian Standards Institution should bring out standards for fertiliser-pesticides mixtures in anticipation of their becoming a part of future consumption pattern.

(Paragraph 49.11.8)

30. Methods of sampling and analysis should be uniform throughout the country and brought within the scope of the Insecticides Act and the Quality Marking System of the ISI. The methods should be periodically reviewed for introducing improvements.

(Paragraph 49.11.11)

31. The Central Insecticides Laboratory should have arrangements for training the States' quality control personnel engaged in drawing and analysis of pesticide samples.

(Paragraph 49.11.11)

32. Attention has to be paid to equip mobile soil testing laboratories for carrying out preliminary pesticide analysis.

(Paragraph 49.11.12)

33. The pesticide analysis laboratories should preferably be located in the campuses of the agricultural universities, so that the latter can assist the laboratories in an advisory capacity.

(Paragraph 49.11.13)

34. Publicity media should be used in order to educate farmers with regard to the existing facilities available for the testing of pesticides and in distinguishing the standard materials from the spurious ones.

(Paragraph 49.11.16)

35. Small amounts instead of bulk quantities of pesticides should be made available in tamperproof containers to reduce risk of adulteration, and to enable small farmers to buy pesticides, which they cannot afford if sold in bulk.

(Paragraph 49.11.17)

36. State departments should maintain emergency stock of pesticides to guard against natural calamities and unforeseen situations.

(Paragraph 49.12.4)

37. The distribution centres are generally opened in demand areas and the places which are easily accessible by railway or road. These defects may be remedied if, while issuing licences, equal opportunities are given to all categories of farmers, especially those of the small ones. The farmers' service society may be entrusted with the task of running inputs, depots, including those of pesticides, so that they become available in time to the members of the Society.

(Paragraph 49.12.5)

38. The same priority as given to fertilisers should be extended to pesticides in the matter of allotment of railway wagons and their movement.

(Paragraph 49.12.6)

39. The godowns and storage facilities available with agencies like the Fertiliser Corporation of India should be given on a priority basis for pesticide storage.

(Paragraph 49.12.7)

40. Subsidy for the purchase of pesticides should be discontinued except in the case of small and marginal farmers. The subsidy, however, may be given (a) for transportation charges of pesticides from railway tracts to distribution points for stabilising price; (b) for aerial spray; (c) for appliances; (d) for spraying pesticides in epidemic areas; and (e) for opening more sale points in backward areas.

(Paragraph 49.12.9)

41. The present state of promotional efforts made by State Governments is not satisfactory. A part of the saving accruing from the withdrawal of subsidy for the purchase of pesticides should be utilised for promotional activities.

(Paragraph 49.12.10)

42. In conformity with the multifarious activities and responsibilities of the DPPQ&S in the Union Ministry of Agriculture and Irrigation, the status of the Plant Protection adviser should be raised to that of a Joint Secretary. A similar upgrading is called for in respect of other officers at the Central and State levels.

(Paragraphs 49.12 11 and 49.12.13)

APPENDIX 49.1

(Paragraph 49.3·12)

Questionnaire

Q. 1(a) What are the recommended plant protection practices for specific pests under different crops? Please mention cropwise pests and their schedule of plant protection practices with doses per unit area. (Data for the last five years may be furnished if there has been change in schedule.)

(b) What are the recommended practices for controlling losses in storage?

Q. 2 What are the basis for formulating such recommendations mentioned in questions 1(a) and 1(b)? Please elaborate.

Q. 3 Give information on cost/benefit ratio, cropwise, by use of pesticides.

Crops	Treatments	Cost of treatment per hectare	Value of increased yield/ hectare	Cost/ benefit ratio (4/3)	Remarks
1	2	3	4	5	6

Q. 4 What is the awareness of the farmers towards cost/benefit ratio?

Q. 5 Trend of Chemicals used in the past, in tonnes.

QUANTITY IN TONNES

Crops treated	Name of chemicals	YEARS						Remarks
		60—61	61—62	62—63	63—64	64—65	65—66	
		66—67	67—68	68—69	69—70	70—71	71—72	

Q. 6 Future trend in consumption of pesticides in tonnes as per State Governments, if any starting from 1972-73.

Crops to be treated	Name of chemicals	YEARS					Remarks
		72-73	73-74	74-75	75-76	76-77	
		77-78	78-79				

Q. 7 What is the basis on which you plan your annual targets for plant protection chemicals and evaluate the achievements?

Q. 8 What is the organisational setup of your Plant Protection Department?

Q. 9 How is the State machinery involved in organising, storing and distribution of pesticides?

Q. 10 What is the system of purchase of pesticides by Government, Cooperatives and Agro-Industries Corporation?

Q. 11 What are the types of agencies involved in storing, distribution and selling pesticides?

Q.12 How are the storing and distribution coordinated between state machinery, selling agents and the farmers?

Q.13 Are the farmers getting timely supplies of pesticides in adequate quantities in your State? What are the remedial measures taken to correct the imbalance, if any, between the demand and supply ?

Q.14 What promotional efforts are made by various agencies to popularise the use of pesticides among the cultivators? Are you satisfied with existing efforts? If not, what improvements are needed? What concrete steps would you suggest to promote the use of pesticides in your State?

Q.15 Have you tried fertilser-pesticides mixtures either as soil application or foliar application ? If so, in what proportions and with what results?

Q.16 Is there any subsidy provioed to the farmers for buying pesticides ? If so, give details, indicating whether you would continue or abolish it.

Q.17 Is there any rate contract provision for selected pesticides in your State ? If so, specify.

Q.18(a) How is the State machinery informed of a pest attack during a particular season?

(b) How often is the information communicated to the farmers and supplemented with adequate plant protection measures?

Q.19 In case of severe widespread attack of a particular pest, how does the State machinery operate? Indicate some case studies, if conducted, on this aspect. Mention measures of aerial sprayings also. What are the difficulties faced in such a situation?

Q.20(a) Have you maintained a record of all outbreaks over a period of years, which assumed an epidemic form? Please mention pest (insect, disease), location and year of occurrence.

(b) Did the State department study the factors responsible for such epidemics? If yes, please indicate studies undertaken and their findings.

Q.21 What is the Centre-State coordination in all matters concerning development of use of plant protection chemicals in your State, particularly for the approval of pesticides cropwise and pestwise?

Q.22 Is there any machinery to undertake scientific evaluation on a continuing bases of plant protection measures in terms of farmers' aptitude and preferences of the practice in the context of overall use of fertilizers and pesticides?

Q.23 Have the epidemic and endemic areas of crops pests been clearly identified in your State? If so, what preventive measures are taken? Is the effort commensurate to meet the situation? If not, what improvements in financial and other resources would you suggest?

Q.24 If there is a *regular appearance* of some pests in specific areas, what system of warning is adopted to relay the information for the benefit of cultivators? Simultaneously, how is it ensured that the requisite pesticides are also made available?

Q.25 How often has recourse been taken to enforce to State Pest Act to meet epidemic situations? What improvements could make the operation of the Act more effective?

Q.26 Do you agree that some pest control measures are best organised on community basis to give demonstrable results, e.g., seed treatment, rodent control, etc.? Are such measures practised in your State? And if so, to what extent?

Q.27 What is your opinion of State support for contract spraying with ground equipment by private parties? Has this been tried in your State? If not, what are special difficulties in supporting the project?

Q.28 What is your view on the effectiveness of aerial pest control operations? Would you prefer it to subsidising similar operations from the ground?

Q.29 How far co-operation is sought of Panchayats in stocking and distributing pest control chemicals and in mounting control campaigns? What is the response from these bodies?

Q.30 What special consideration, if any, is shown in matter of State purchase from firms who take active interest in promotional activities in plant protection and have good sales outlet?

Q.31 Are farmers hesitant to use pesticides because of their alleged poisonous nature? What steps would you suggest to overcome this inhibiting factor?

Q.32 What steps are you taking or you plan to take to minimise the hazards of pesticides arising out of their improper use :

(i) By organising educational programmes for the farmers,

(ii) By monitoring pesticides residues in treated crops, grains, milk, eggs, and fish, etc.,

(iii) By promoting use of safer formulations, like granules, and

(iv) By any other means?

Q.33 How far are plant protection officials trained to recognise symptoms of pesticides poisoning and trained to administer first-aid measures? Do the plant protection centres stop special antidote medicines for use by medical practitioner(s)?

Q.34 What arrangements exist for intensive inservice training of plant protection workers so that their knowledge is kept up-to-date?

Q.35 Do you have a manual listing duties and responsibilities of plant protection officials at various levels? If so, furnish a copy.

Q.36 What procedure is followed in your State for testing the biological efficacy of a pesticide preparation with a view to approving the same for use? Are the existing facilities adequate for the work?

Q.37 Is product approval given to individual firms or does it *ipso facto* imply general approval of similar products of other firms? How much time does it take to appove a product? Is any fee charged for such work?

Q.38 How far do you rely on the data on biological efficacy provided by private firms and what credence is given to it?

Q.39 Are researches being undertaken in your State on sustained basis to evaluate the effect of pesticides on beneficial soil microflora and soil fertility? If so, give particulars.

Q.40 What is your experience in use of chemicals polluting the environment? Would you prefer increased use of pesticides for years to come? If yes, please state why? If not, please state why and what measures would you like to adopt?

APPENDIX 49.1—(Concld.)

ANNEXURE I

Statement on major specific pests which cause losses in yield (1950-51, 55-56, 60-61, 65-66 to 71-72)

Name of State :

Crops (specify)	Variety (HYV/ local)	Pests (specify)	Area Affected	Approx. loss yield/ hectare	Amount of loss saved and/or quantity increase in yield by use of pesticides	Remarks
1	2	3	4	5	6	7

Describe briefly methodology used for arriving at figures under columns 4, 5 and 6.

ANNEXURE II

Statement on Storage loss (1950-51, 55-56, 60-61, 65-66 to 71-72)

Grains stored (specify)	Pests (specify)	Approx. loss	Amount of loss compensated by use of pesticides	Remarks
1	2	3	4	5

Describe in brief methodology used for arriving at figures under columns 3 and 4.

APPENDIX 49·2

(Paragraph 49·3·2)

Some Records of Felt Loss Due to Diseases in India

Crop	Disease	Loss	Reference
1	2	3	4
paddy .	bacterial leaf blight (*Xanthomonas oryzae*)	22·7%	Anon. 1964, quoted from Srivastava, 1972. *Indian Phytopath. 25* : 1—16.
		50%	Rao and Kauffman 1971; same as above.
		6—60%	Srivastava *et al.*, 1966 *Indian Fmq. 16* : 15 Srivastava & Rao, 1968. *Proc. 1st Summer Inst. Plant Dis. Control.* ICAR, 1968, p. 180.
	helminthosporiose (*Cochliobolus miyabeanus*)	15—19%	Padmanabhan *et al*, 1948. *Indian Phytopath*. 1 : 34—37.
	Udbatta (*Ephelis oryzae*)	10—11%	Mohanty, 1964. *ibid.* 17 : 308—316.
	bacterial streak (*Xanthomonast transluscence* sp. *oryzae*)	5—30% in MP	Chand *et al.*, 1971. *Proc. Symp. Epidem Forecast. Control Plant-Dis. INSA Bull.* 46 1973. p. 309—313.
wheat .	rusts	10—15%	Pal, 1968. *Proc. 1st Summer Inst. Plant Dis. Control.* ICAR, p. 1—4.
	black rust (*Puccinia graminis-tritici*)	2 million tonnes	Joshi *et al.*, 1974. *Current Trends in Plant Path.* Ed. S. P. Raychaudhury & J. P. Varma, Dept. Bot., Univ. Luck., P. 150—159.
	brown rust (*Puccinia recondita*)	1 million tonnes	Ditto.
	rust	Rs. 40 million annually	Barclay, 1890. quoted from Joshi *et. al.*, 1974, *ibid.* p. 150-159.

APPENDIX 49·2—(Contd.)

1	2	3	4
wheat . (contd.)	rust (contd.)	Rs. 60 million annually	Mehta, 1940, quoted from Joshi *et al.*, 1974 *ibid.* p. 150—159
		8—20%	Joshi *et al.*, 1974, *ibid.* p. 150—159.
	loose smut (*Ustilago nuda tritici*)	1 million tons	Suryanarayana, 1971. *2nd Intern. Symp. Plant Path.* (*Abstr.*) IPS. IARI. p. 22—23.
	tundu (*Anguini tritici* and *Coryne bacterium tritici*	2—5% 50—60% (1965-66)	Raychaudhuri, 1968. *Indian Phytopath.* 21 : 1—13.
maize .	all diseases	370, 645 tonnes	Payak and Renfro 1974. *Current Trends in Plant Path.* Ed. S. P. Raychaudhuri & J. P. Varma, Dept. Bot., Univ. Luck., p. 166—170.
		10—12%	Payak and Renfro, 1968. *Proc. 1st Summer Inst. Plant Dis. Control.* ICAR p. 163.
		5—12%	Payak *et al.*, 1973. *Indian Fmg.* July 1973.
	mosaic (virus)	32%	Seth *et al.*, 1968. *Proc. 1st Summer Inst. Plant Dis. Control* ICAR p. 165—166.
jowar .	grain smut (*Sphacelotheca sorghi*)	50%	Lucy Channamma and Delvi 1966. *Proc. Symp. Dis. Rice, Maize, Sorghum* and *Millets*, IPS. Bull. No. 3 p. 1—2.
		326,000 tons	Suryanarayana, 1971. *2nd Intern. Symp. Plant Path.* (*Abstr.*) IPS. IARI. p. 22—23.

APPENDIX 49.2—(Contd.)

1	2	3	4
bajra	ergot (*Claviceps microcephala*)	2—3%	Sundaram, 1968. *Proc. 1st Summer Inst. Plant Dis. Control*. ICAR p. 164—165.
	green ear (*Sclerospora graminicola*)	5—10%	Suryanarayana, 1962. *Indian Phytopath*. *15* : 247—249.
barley	stem and stripe rusts	600,000—700,000 tons	Mehta, 1949. quoted from Ahmed *et. al*., 1972. *Indian Phytopath*. *25* : 434—488.
	covered smut (*Ustilago hordei*)	2—5% 20—40%	Bedi and Singh, 1972, *ibid*. *25* : 101—103.
cereals	smuts	2—5%	Pal, 1968. *Proc. 1st Summer Inst. Plant Dis. Control*, ICAR p. 1—4.
sugarcane	all diseases	Rs. 300—450 million p.a.	Singh, 1968. *ibid*. p. 150.
	grassy shoot	50%	Seth, 1968. *ibid*. p. 151.
potato	late blight (*Phytophthora infestans*)	15—25%	Pal. 1968. *ibid*. p. 1—4.
		31·5% (during 17 years in Simla Hills)	Dutt, 1968. *ibid*. p. 65.
		55·8% in plains	Dutt, 1968. *ibid*. p. 65.
		15—50%	Majid, 1950, quoted from Roy & Das, 1968. *Indian Phytopath*. *21*(2) : 232—233.
		10—65%	Majid, 1952, quoted from Roy and Das, 1968. *ibid*.
	brown rot (*Pseudomonas solanacearum*)	50%	Dutt *et. al*., 1968. *Proc. 1st Summer Inst. Plant Dis. Control*. ICAR p. 128.

APPENDIX 49.2—(Concld.)

1	2	3	4
groundnut	tikka (*Cercospora personata, C. arachidicola*)	15—50%	Chohan and Singh, 1973, quoted from Chohan, 1974. *Current Trends Plant Path.* Ed. S. P. Raychaudhuri & J. P. Varma, Dept. Bot., Univ. Luck., p. 171—184.
	stem rot (*Sclerotium rolfsii*)	27%	Mathur, 1953, Singh and Mathur 1953 and Kang, 1957, quoted from Chohan, 1974. *Current Trends Plant Path.* Ed. S. P. Raychaudhuri & J. P. Varma, Dept. Bot., Univ. Luck., p. 171—184.
	collar rot (*Aspergillus niger, A. pulverulentus*)	40%	Chohan, 1974. *ibid.* p. 171—184.
grape .	anthracnose (*Gleosporium ampelophagum* or *Sphaceloma ampelinum*)	15%	Bedi, *et al.*, 1969. *Indian Phytopath.* *22*(1) : 155—156.
cotton .	bacterial leaf blight (*Xanthomonas malvacearum*)	20—30%	Singh and Verma, 1973. Pesticides. *7*: 16—17.
tea .	blister blight (*Exobasidium vexans*)	180 million pounds in India for 6 years since 1946	Venkata Ram, 1971. *Proc. Epidem. Forecast Control Plant Dis. INSA Bull.* *46*. 1973. p. 377—383.

APPENDIX 49·3

(Paragraph 49·3.2)

Some Records of Felt Loss[1] Due to Insect Pests In India

Crop or crop product	Pest	Loss %
1	2	3
sugarcane	all pests	10
sugarcane (as raw sugar)	pyrilla, borers, termites	16
foodgrains	all pests	10—15
wheat	wheat weevils	1·6
	pests and other causes	3
rice	pests and other causes	1·1
	swarming caterpillar, rice stem borer, rice caseworm, rice bug, rice grasshopper, rice hispa	10
other cereals including jowar, bajra, ragi, small millets, wheat and barley	grasshoppers, termites, cutworms, hairy caterpillar, stem borers and army worm	7
jowar	pests and other causes	5
bajra	do.	5
maize	do.	5
ragi	do.	5
barley	do.	2
small millets	do.	2·5
pulses (including gram)	red hairy caterpillar, pod borer, gram caterpillar and cutworms	5
gram	pests and other causes	2
other pulses	pests and other causes	2·5
potatoes	do.	17
potatoes	jassids, aphids, cutworms, white grubs	5
tobacco	tobacco caterpillar, stem borer, aphids, cutworms	5
groundnut (nut in shell)	hairy caterpillar, termites	5
other oilseeds including mustard, castor, sesamum and linseed	mustard aphids, hairy caterpillar, semilooper, capsule borer, leaf and pod caterpillar	5

[1] Pradhan. S. 1964. Assessment of Losses caused by Insect Pests of Crops and Estimation of Insect Population. Entomology in India. 1964, Silver Jubilee Number of the Indian Journal of Entomology.

APPENDIX 49·3—(Concld.)

1	2	3
jute	semilooper, hairy caterpillar, jute apion	5
cotton	bollworms, jassids, cotton leaf roller, cotton stem borer, aphids, white fly.	18
tea	tea mosquito looper caterpillar, leaf eaters, aphids, termites, thrips	5
coconut	black headed caterpillar, red palm weevil, rhinoceros beetle	5
coffee	green bug, borers, mealy bugs, cutworm	8
chillies	chilli thrips	10
pepper	mealy bug, flea beetle	5
miscellaneous non-forecast crops, vegetables, fruits, etc.	aphids, caterpillars, borers, grasshoppers, termites, cutworms, bugs, fruit flies, thrips	6
fruits	pests and other causes	25

APPENDIX 49·4

(Paragraph 49·3·2)

Some Records of Felt Loss and Loss Estimation Due to Nematodes in India

Felt loss

Crop	Loss	Reference
wheat .	Rs. 40,000,000/- in Rajasthan	Seshadri, 1973. *Natn. Symp. Agric. Res. Dev. since Independence*, March, 1973
barley .	Rs. 30,000,000/- in Rajasthan	Do.

Loss estimation

Crop	Nematode	Loss	Reference
1	2	3	4
wheat .	ear cockle (*Anquina tritici*)	Rs. 75,000,000	Seshadri, 1973 *National Symp. Agric. Res. and Dev. since Independence*, March, 1973.
coffee .	*Pratylenchus coffeae*	Rs. 20,000,000	Do.
sugarcane	Nematodes	22—78%	Singh, 1968. *Proc. 1st Summer Inst. Plant D s. Control*, ICAR, p. 158.

APPENDIX 49·5

(Paragraph 49·3·2)

Some Loss Estimation Due to Diseases Carried out in India

Crop	Disease	Loss	Reference
1	2	3	4
wheat .	leaf blight (*Alternaria triticina*) (during one year)	45—90% Vars, Kenphad 21, Kenphad 32 and NP 830.	Chenulu and Singh, 1964. *Indian Phytopath.* *17* : 254—256.
	brown and black rust (*Puccinia recondita*, *P. graminis tritici*)	22. 1-48·7% Var. C. 518	Grewal and Dharam Vir, 1959. *ibid.* *18* : 225.
	spot blotch (*Helminthosporium sativum*) (during 1 year)	3·6—32·4% Vars. NP 884 NP 852, Lerma Rojo, Sonora 64, S 227.	Nema and Joshi, 1971. *ibid.* *24* : 526—582.
	blight (*Helminthosporium speciferum*)	72% Var. Lerma Rojo 63% Var. S 227	Singh and Singh, 1971. *Abstr. 2nd Intern. Symp. Plant Path.* IPS IARI. p. 76-77.
	black rust (P. *graminis tritici*) (during 1 year)	1968-69 7·9–11·2% in early sown crop; 15·8–19·3% in late sown crop Var. S 227 1969-70 (*a*) 7·0–8·0% in early sown crop. 10·0–16·7% in late sown crop Var. S 227 (*b*) 5·6—8·9% in late sown crop. Var. Sonora 64	Pathak and Joshi, 1971. *Abstr. Post Symp. Group Discussions at ' Simla, Kanpur, Poona, Hyderabad, Bangalore* and *Cuttack, IPS* p. 4-5.
	rusts	upto 78%	Prasada, 1960. *Indian Phytopath.* *13* : 1
maize .	helminthosporium blight	27·6–90·7%	Chenulu and Hora, 1962, *ibid.* *15* : 235.
	Mosaic (Virus)	31·8%	Raychaudhuri, *et. al.*, 1966 *Proc. Symp. diseases, rice, maize, sorghum* and *millets,* IPS. Bull. No. *3* p. 26–31.

APPENDIX 49·5—(Contd.)

1	2	3	4
jowar .	grain smut (*Sphacelotheca sorghi*)	18,680 tonnes (1962) 6,930 tonnes (1964)	Mathur and Dalela, 1971. *Indian Phytopath.* 24, (1) : 101—104.
bajra .	green ear (*Sclerospora graminicola*	55,450 tonnes (1962) 45,370 tonnes (1964)	Mathur and Dalela, 1971 *ibid.* 24(1) 101—104.
mustard .	sesamum phyllody (Virus)	86% Var. *Brassica campestris L. var. toria*	Bindra, 1971. *Abstr. 2nd Intern. Symp. Plant Path.* IPS. IARI p. 25-26.
	wilts	30—60%	Rai and Singh, 1971. *Abstr. Post Sym.*
	root rots	5—10% vars. *B. campestris* var. brown sarson, *B. campestris* var. yellow sarson, *B juncea.*	*Group Discussions at Simla, Kanpur, Poona Hyderabad, Bangalore* and *Cuttack* IPS p. 4-5.
linseed .	rust (*Melampsoralini*)	73—100% Vars. NP 12, NP 21	Hora, *et. al.*, 1962 *Indian Oilseeds* J. 6 : 196
groundnut	mosaic (Virus)(during 4 years)	29—100% by Kernel wt and 22—97% pod wt. var. Punjab-1.	Chenulu *et. al.*, 1966. *Indian Phytopath 19* (2) : 194—197.
pea .	powdery mildew (*Erysiphe polygnni*) (during 2 years)	21—31% by pod number 26—47% by pod weight local var.	Munjal *et. al.*, 1963. *ibid. 16* : 268—270.
coriander	powdery mildew (*Erysiphe polygoni*) (during 2 years)	15—20% local var.	Srivastava *et. al.*, 1971. *ibid. 24* (3) : 437—440.
	stem gall (*Protomyces macrosporus*)	15%	Gupta, 1954 *ibid.* 7 : 53—60.
	do. (during 2 years)	0·09—11·7% vars. 18 varieties	Gupta and Sinha, 1973, *ibid.* 26 (2): 337—340.
potato .	late blight (*Phytophthora infestans*)	11%	Dutt, 1971. *Abstr. Post Symp. Group Discussions at Simla, Kanpur, Poona, Hyderabad, Bangalore* and *Cuttack*, IPS p. 1—2.

APPENDIX 49·5—(Concld.)

1	2	3	4
	late blight (*Phytophthora infestans*) (during 2 years)	58·2%	Vasudeva and Azad, 1952. *Emp. J. exp. Agric.* 20 : 293.
apple .	white root rot (*Dematophora necatrix*) (during 1 year, 1963)	10% in nursery. 2% in non-bearing plants 1·5% in bearing Rs. 1·3 million annual loss.	Agarwala and Sharma, 1966. *Indian Phytopath. 19* (1) : 82—86.
papaya .	fruit rot (*Phytophthora parasitica*)	2,160 Kg/acre* (1969) 3,888 Kg/acre* (1970)	Sohi and Sridhar, 1971. *Abstr. Post Symp. Group Discussion at Simla, Kanpur, Hyderabad, Bangalore* and *Cuttack* IPS p. 25.
	stem rot (*Pythium aphanidermatum*)	10—35%	Jani and Patel, 1971 *ibid*, p. 20.
large cardamum	chirke (virus)	85·20% in fruits 80·09% in seeds	Raychaudhuri and Ganguly, 1965. *Indian Phytopath 18* (4) : 73—377.
paddy .	helminthosporiose	19·2—41·2% (in terms of paddy) 14·2—40·6 % (in terms of rice) Var. IR 5.	Vidyasekaran *et. al.* 1971. *Proc. Indian Natn. Sci. Acad. Part B, 37* : 487—493.
water melon	alternaria blight (*Alternaria cucumerina*)	7-54%	Prasada, *et al.*, 1971. *ibid. 37* : 301—308.

* For calculating loss in kg/hectare multiply by 2.47.

APPENDIX 49·6

(Paragraph 49·3·2)

Some Loss Estimations Due to Insect Pests Carried Out in India [1,2]

Crop or crop product	Pest	Loss	Reference
1	2	3	4
paddy .	stem borer (*Tryporyza incertulas*)	29% 80—400 lbs/acre*	Banerjee, 1964 Khan and Murthy, 1955.
		0·5—12%	Puttarudriah, 1962
		44·15%	Israel *et. al.*, 1962.
	hispa (*Dicladispa armigera*)	6·76%	Basu and Banerjee, 1957.
jowar .	all pests	77·6% (Kharif, 1965) 83·7% (Kharif, 1966).	Pradhan, 1971.
Jute .	all pests	5%	Dutta, 1964.
cotton .	thrips	232 lbs/acre*	Bhat and Patel, 1954.
sugarcane	top borer (two years) (shoots)	5·7% and 2·4% 12·7% (var. Co. 321) 10·7% (var. Co. 421)	Rajani, 1961, Siddiqi, 1961.
	Chilotraea auricilla stem borer	16% (about 105** mds. of cane per acre)	Kulshreshtha, *et. al.*, 1957.
	(during 2 years)	2·3% and 5·8%	Rajani, 1961.
	stem and root borers (Shoots)	15% (var. Co. 321) 22·5% (var. 421)	Siddiqi, 1961.
	root borer (during 2 years)	31·1% and 4·2%	Rajani, 1961
	all borers (shoots)	25·7% (var. Co. 321) 33·2% (var. Co. 421)	
	(net loss at shoot stage)	18·0% (var. Co. 321) 22·2% (var. Co. 421)	Siddiqi, 1961
	(millable canes)	19·0% (var. Co. 321) 14·2% (var. Co. 421)	
	(total loss due to borers)	37·0% (var. Co. 321) 36·4% (var. Co. 421)	
	borers	4% in weight of canes	Haldane, 1937
	termites (during 2 years)	1·3% and 0·8%	Rajani, 1961
	all pests	7·90% (var. Co. 331)	

APPENDIX 49·6—(Contd.)

1	2	3	4
sugarcane—*contd.*			
		12·81% (var. Co. 210)	
		9·10% (var. Co. 213)	
		11·62% (var. Co. 313)	Pruthi *et. al.*, 1939
		3·92% (var. Co. 299)	
mustard .	*Lipaphis erysimi* (during 3 years)	51·6%, 71·5% and 87·9%.	Pradhan *et. al.*, 1960
coconut .	*Oryctes rhinocerus*	4·9% nuts	Ramachandran, 1961

Entomology in India. 1964. Silver Jubilee number of the Indian Journal of Entomology.

Pradhan. S. Assessment of Losses Caused by Insect Pests of Crops and Estimation of Insect Population. *Ibid.*

*For calculating loss in kg/hectare multiply by 1.12.

**For calculating loss in tonnes/hectare multiply by 0.092.

APPENDIX 49·7

(paragraph 49·3·2)

Some Loss Estimation Due to Weeds Carried Out in India[1]

Crop	Variety	Yield : quintals/ha unweeded	manual or mechanical control	chemical control	Average reduction due to weeds %
1	2	3	4	5	6
wheat	PbC 591	9·5	13·0	11·1	21·5
	N.P. 718	12·9	14·7	16·1	16·4
	—	20·7	21·9	22·2	6·3
	N.P. 718	13·3	15·1	15·5	13·1
	N. P. 718	16·7	25·0	26.2	34·8
	N. P. 718, N. P. 823, N. P. 824	21·6	24·4	23·5	9·9
	..	15·3	18·5	..	17·3
	N. P. 718	28·4	35·1	41·5	25·8
	Sonora 64	40·2	45·9	50·9	16·9
rice		13·7	18·9	..	27·5
	T 141	41·8	45·5	46·5	9·1
		10·2	21·0	..	51·4
		10·1	13·2	..	23·4
	..	26·3	31·7	30·2	14·9
	N. P. 130	31·5	..	51·8	39·0
	Dular	4·4	7·3	3·1	38·3
	TN-1	54·0	67·0	71·0	21·7
	T 9	15·0	16·7	22·3	23·1
maize	Jaunpur	17·9	..	34·9	48·2
	Ganga 101	22·3	33·9	39·4	39·2
	Pusa Yellow	4·5	17·4	17·3	74·0
	Malan (fodder)	217·6	..	743·4	69·2
	Ganga 101	22·4	42·5	42·1	47·0
	Ganga 101	31·9	53·8	51·0	35·8
	Ganga 101	23·9	30·3	37·5	29·5
	Ganga 101	21·8	28·4	34·5	30·6
sorghum	..	10·9	16·5	13·8	27·8
	..	7·6	8·2	8·1	6·2
	RS 610	13·8	19·1	20·6	30·3
	Senner	13·4	26·3	18·6	40·2

APPENDIX 49·7—(Contd.)

1	2	3	4	5	6
bajra	HB-1	18·9	21.4	22.5	13.7
potato	Darjeeling Round Red	239.1	..	255.4	6.4
	Darjeeling Round Red	218.6	..	273.1	19.9
	Up-to-date	68·9	85·3	106·5	11·0
	Up-to-date	79·3	106·6	133·3	33·9
	Up-to-date	92·8	155·6	146·0	38·6
	..	9·2	..	35·0	81·9
peas	..	17·6	25·1	29·6	35·5
	Bonneville	15·9	20·1	22·5	25·3
	Bonneville	22·9	30·9	32·6	27·0
carrot	Nantes	15·6	67·0	74·9	78·2
	Nantes	55·6	179·3	193·5	70.2
onion	Pusa Red	80·4	251·3	239·8	67·2
peanut	Spanish improved variety (erect type)	25·2	37·7	..	32·9
	TMV 2 (bunch type) and TMV 3 (spreading type)	150·0	227·2	..	34·0
	TMV 2	2·6	3·9	3·5	29·7
linseed	NPRR 9	11·1	17·1	19·8	39·1
	NPRR 9	9·2	12·7	13·7	30·9
	Mukta	6·3	11·1	8·9	37·9
	NPRR 9	10·7	15·7	16·7	33·9
gram	..	..	13·6	15·8	7·8
sugarcane	Co 419	1,541·6	..	1,795·7	14·1
	Co 647	660·7	960·9	978·7	31·3
	Co 647	587·0	853·6	864·4	31·5
	Co 647	185·4	655·7	..	71·7
	CoS 510	518·0	611·0	584·4	13·3
	CoS 510	564·3	679·2	642·4	21·1
	Co 1104	670·5	757·1	926·4	20·3
	Co 764	258·0	828·77	740·8	54·4

APPENDIX 49·7 (Concld.)

1	2	3	4	5	6
cotton . .	Hyderabad Gaorani	2·5	6·4	..	61·0
	F.216 . . .	2·3	2·9	..	20·7
	F.216 . . .	0·08	0·14	0·11	33·3
	Virnar . . .	6·2	10·3	..	39·8
	Gaorani . .	2·5	6·0	..	58·3
	F.216 . . .	9·1	15·6	16·0	42·4

1. 1968. Mani. V. S., K. G. Gautam and T. K. Chakraborty, Losses in crop yield in India due to weed growth, *14*(2) ; 142-158. *PANS* (*C*)

APPENDIX 49·8

(Paragraph 49·3·2)

I—Some Loss Estimation Due to Rats under Field Conditions Carried Out in India

Crop	Loss	Reference
1	2	3
jowar . .	5·85%	Report of the Coordinated Scheme for Research on the Study of Field Rats, 1965-66. ICAR.
groundnut .	20·1 Kg/ac*	Do.
wheat . .	2·36%	Do.
paddy . .	1·14—30·5%	Do.
coconut .	up to 17%	Do.
barley . .	147 Kg/ha	Srivastava, 1966. *Labdev J. Sci. Tech.*, 4 : 197-200.
sugarcane .	1·52—16·7%	Srivastava, 1968. Rodent Control for Increased Food Production. Rotary Club (West) Kanpur. pp. 152.
paddy . .	0·63—7·14%	Do.
jowar . .	5·9%	Srivastava and Pandya, 1968. *Proc Intern. Symp. Bionomics & Control of Rodents*. Ed. S. L. Perti Y. C. Wal & C. P. Srivastava Sci.Tech.Soc.,Kanpur, May 1971. p.32-34.
arhar . .	6·5%	Do.
barely . .	4·9%	Do.
gram . .	4·0%	Do.
wheat . .	10·29 Kg/ac.	Bindra and Prem Sagar, 1968 *ibid.* pp. 28-31.
groundnut .	12—31 Kg/ac.	Do.
sugarcane .	65—230 Kg/ac. (gur)	Do.

* For calculating loss in kg/ha multiply by 2.47.

APPENDIX 49·8—(Concld.)

(Paragraph 49·3·2)

II—Damage Caused by Rodents to Various foodgrains Under Field Conditions in Uttar Pradesh[1]

Crop	Damage (million tonnes)	As percentage of crop
1	2	3
paddy	0·396	7·5
wheat	0·350	2·9
gram	0·237	4·0
barley	0·144	6·0
peas	0·1	2·0
maize	0·1	14·0
jowar	0·081	6·0
bajra	0·092	5·0
vegetables	difficult to estimate	6·0

[1]Dr. A. S. Srivastava—Personal communication.

APPENDIX 49·9

(Paragraph 49·3·4)

Cropwise Average Yields and Percentage Losses Due to Insect Pests and Diseases of High Yielding Varieties during Kharif 1967 and 1968. [1],

Crop	State	Average yield in quintals		Percentage loss due to insect pests and diseases	
		Kharif		Kharif	
		1967 (per ha.*)	1968 (per ha.)	1967	1968
1	2	3	4	5	6
paddy . .	Andhra Pradesh .	33·10	48·0	30·40	25·6
	Assam . . .	..	39·5	..	24·55
	Bihar . . .	12·40	32·0	44·26	18·26
	Jammu & Kashmir	..	61·4	..	..
	Kerala . . .	20·20	27·8	45·14	11·44
	Madras* . .	22·75	39·9	44·52	29·67
	Maharashtra . .	13·39	17·7	12·76	23·08
	Mysore** . .	15·40	58·0	56·21	47·04
	Orissa . . .	9·56	29·00	71·33	42·71
	Punjab . . .	13·88	48·2	56·39	3·13
	Uttar Pradesh .	38·43	35·9	21·54	23·25
	West Bengal . .	32·55	37·4	20·93	12·34
	All States . .	24·33	39·9	43·95	19·28
maize . .	Bihar . . .	18·75	26·4	10·37	7·08
	Madhya Pradesh .	1·28	20·0	48·12	..
	Maharashtra .	17·81	...	..	..
	Punjab . . .	30·13	29·9	3·46	5·08
	Uttar Pradesh .	11·61	9·9	18·93	11·38
	All States . .	20·43	45·0	16·24	6·58
bajra . .	Gujarat . .	10·52	9·7	30·00	27·38
	Haryana . .	16·60	9·7	..	..
	Maharashtra . .	7·46	7·5	16·50	20·00
	Rajasthan . .	..	7·2	..	..

* Now Tamil Nadu

** Now Karnataka

APPENDIX 49·9—(Concld·)

1	2	3	4	5	6
	Uttar Pradesh .	10·00	13·1	78·98	10·41
	All States . .	11·09	8·7	29·41	23·44
Jowar . .	Madhya Pradesh .	10·47	12·7	14·93	11·92
	Maharashtra . .	6·15	10·6	38·76	27·39
	Mysore . .	20·58	0·9	23·27	125·59
	All States . .	7·88	10·6	31·85	26·92

Evaluation Study of the High Yielding Varieties Programme. Report for the Kharif—1967, Programme Evaluation Organisation. Planning Commission. Government of India. August 1968, PEO Publication No. 62 pp. 222—224.

[2]. Report on Evaluation of the High Yielding Varieties Programme. Kharif—1968. Programme Evaluation Organisation, Planning Commission, Government of India, June 1969. PEO Publication No. 67 pp. 206—209.

* Data converted from per acre to per hectare.

APPENDIX 49·10

(Paragraph 49·3·4)

Cropwise Average Yields and Percentage Losses Due to Insect Pests and Diseases of High Yielding Varieties During Rabi 1967-68 and 1968-1969[1],[2]

Crop	State	Average yield in quintals		Percentage loss due to insect pests and diseases	
		Rabi		Rabi	
		1967-68* (per ha.)	1968-69 (per ha.)	1967-68	1968-69
1	2	3	4	5	6
paddy . .	Andhra Pradesh .	43·37	47·35	17·56	26·87
	Kerala . . .	27·19	27·60	5·11	10·52
	Madras@ . .	29·15	31·33	20·94	21·18
	Mysore@@ . .	39·00	44·48	14·15	..
	Orissa . . .	53·62	59·38	..	9·80
	West Bengal . .	43·74	65·66	8·17	6·40
	All States . .	42·16	44·36	14·28	20·73
jowar . .	Maharashtra . .	19·83	19·42	28·93	40·30
	Mysore@@ . .	24·28	0·30	27·41	52·00
	All States . .	21·91	16·21	27·82	41·84
wheat . .	Bihar . . .	16·57	9·91	5·00	..
	Haryana . .	28·40	26·64	8·00	..
	Maharashtra . .	..	18·09	..	..
	Punjab . . .	27·57	25·90	4·70	4·15
	Rajasthan . .	29·44	26·81	14·44	..
	Uttar Pradesh .	22·60	22·29	16·70	3·33
	All States . .	26·55	24·64	8·30	3·58

[1]. Evaluation Study of the High Yielding Varieties Programme. Report for Rabi 1967-68—wheat, paddy and jowar. Programme Evaluation Organisation, Planning Commission, Government of India, 1968. PEO Publication No. 65 pp. 91-92 and 122-123.

[2]. *Ibid.* 1968-69. PEO Publication No. 68 pp. 166—169.

@ Now Tamil Nadu @@ Now Karnataka.

*Data converted from per acre to per hectare.

APPENDIX 49·11

(Paragraph 49·3·5)

Percentage Loss in Yield Due to Different Insect Pests and Diseases[1]

District	Pest/disease	Crop season	Percentage loss[2]	S. E.	Av. incidence[3]	S. E.
1	2	3	4	5	6	7
Cuttack .	white earheads due to borers	sarad[3] (LDV)	1·01	0·50	0·83	0·07
	dead hearts due to stemborers	dalua[4] (MDV)	3·23	1·17	2·43	0·13
	helminthosporiose .	sarad (LDV)	12·89	2·63	1·42	0·05
	infected earheads due to blast	dalua (MDV)	2·10	0·99	0·41	0·04
Thanjavur .	white earheads due to bores	samba[5] (LDV)	2·24	0·76	1·95	0·05
	dead hearts due to stemborer	samba (LDV)	1·51	0·73	1·73	0·08
	earheads damaged by rats	kuruvai[6] (SDV)	2·91	0·84	1·90	0·16
	earheads damaged by rats	kuruvai (MDV)	1·38	0·29	1·90	0·16
	earheads damaged by rats	thaladi[7] (LDV)	2·96	0·64	2·22	0·11
	tillers cut by rats	kuruvai (MDV)	1·66	0·51	1·28	0·07
	tillers cut by rats	samba (LDV)	1·63	0·31	1·23	0·08
	infected earheads due to helminthosporiose	samba (LDV)	5·44	0·76	1·82	0·12
	infected earheads due to helminthosporiose	thaladi (LDV)	2·48	0·74	2·11	0·14
West Godavari	white ear-heads due to borers	kharif (LDV)	4.56	0.85	4.65	0.13
	white earheads due to borers	rabi (MDV)	5.15	1.57	4.99	0.18

APPENDIX 49.11 (Concld.)

District	Pest/disease	Crop season	Percentage loss[2]	S. E.	Av. incidence[2]	S. E.
1	2	3	4	5	6	7
West Godavari —contd.	infected ear heads due to helminthosporiose	kharif (LDV)	2.99	0.08	13.49	0.34
	infected ear heads due to helminthosporiose	rabi (MDV)	6.67	1.97	15.66	0.59
	infected ear heads due to blast	kharif (LDV)	1.64	0.44	1.69	0.08
	infected ear heads due to blast	rabi (MDV)	2.40	0.94	2.23	0.13

1. Consolidated report of the 'Pilot sample survey to estimate the incidence of pests and diseases on paddy crop'. Conducted in Cuttack (1959—62). Thanjavur (1962—66) and West Godavari 1963—67) district. IARS.

2. For district.

3. sarad, or winter crop, is sown in May-June and harvested in Dec.-Jan.

4. dalua, or summer crop is sown in Jan-Feb. and harvested in May-June.

5. samba is sown in July-Aug and harvested in Dec- Jan.

6. kuruvai is sown in June and harvested in Sep-Oct.

7. thalad)is sown in Sept-Oct and harvested in Feb.

APPENDIX 49.12

(Paragraph 49.3.6)

Crop wise Losses Due to insect Pests and Diseases as Reported by States

(per hectare)

Crop	State	Loss due to insect pest and diseases		
		1970-71	1971-72	1972-73
1	2	3	4	5
paddy	Andhra Pradesh	1485 kg	1550 kg	1400 kg
	Karnataka	7%	3–15%	4–6%
jowar	Andhra Pradesh	160 kg	152 kg	186 kg
	Karnataka	10%	5–15%	4–15%
groundnut	Andhra Pradesh	480 kg	570 kg	414 kg
	Karnataka	7%	1–17%	3–14%
castor	Andhra Pradesh	80 kg	35 kg	34 kg
	Karnataka	..	..	4–12%
cotton	Andhra Pradesh	20 kg (lint)	36 kg	28 kg
	Karnataka	7%	5–32%	6–12%
sugarcane	Andhra Pradesh	15.20 MT	23.60 MT	41.20 MT
	Karnataka	8%	5–35%	3–13%
tobacco	Andhra Pradesh	240 kg	352 kg	294 kg
	Karnataka	12%	5–12%	2–7%
chillies	Andhra Pradesh	284 kg	220 kg	200 kg
	Karnataka	15%	6–13%	5–15%
ragi	Karnataka	9%	5–10%	2–10%
maize	Karnataka	8%	3–10%	3–8%
bajra	Karnataka	9%	4–15%	5–18%
wheat	Karnataka	7%	4–7%	3–15%
vegetables	Karnataka	9%	4–15%	5–8%
pulses	Karnataka	7%	13–15%	3–10%
redgram	Andhra Pradesh	75 kg	45 kg	43 kg
safflower	Karnataka	..	..	3–6%
fruit crops	Karnataka	..	..	3–7%

1-Compiled from replies received from States to NCA Questionnaire on Pesticides (Appendix 49.1).

APPENDIX 49.13

(Paragraph 49.3.12)

I. Serious and Moderate Insect Pests of Paddy Crop

State	Information from States and from literature
Andhra Pradesh	SB, GM, H, GH, *GB*, *GLH*, *WLH*, MB, PH, *Sc*, *CaW* AW, LR, SK, BB, RW
Assam	Sc. H, *GB*, *GLH*, MB, SB, *CAW*, AW, SK, BB, *GH*
Bihar	GLH, SB, Sc, *GB*, MB, PH, *CaW*, *GM*, *GH*,
Gujarat	*GB*, SB, *CaW*, *GH*
Haryana	*GB*, SB, *CaW*, *GH*
Himachal Pradesh	*GB*, SB, *GH*
Jammu & Kashmir	*GB*, SB, *GH*
Karnataka	MB, GM, GH, *GB*, *GLH*, *WLH*, PH, SB, *CaW*, SK' BB, RW, AW, LR,
Kerala	*GB*, *GLH*, *WLH*, PH, SB, *CaW*, AW, LR, BB, RW, *GH*
Madhya Pradesh	*GB*, *GLH*, MB, PH, SB, *Sc*, *CaW*, AW, *GH*
Maharashtra	AW, GM, *GB*, *GLH*, SB, *CaW*, LR, SK, BB, *GH*
Manipur	*GB*, SB, *CaW*, *GH*, AW
Nagaland	GLH
Orissa	GB, WLH, SB, Sc, GM, H, GH, *GLH*, MB, PH, *CaW*, AW, LR, SK, BB, RW
Punjab	*GB*, SB, *CaW*, SK, RW, *GH*
Rajasthan	GH, *GB*, SB, *CaW*, AW
Tamil Nadu	GB, *GLH*, *WLH*, MB, PH, SB, *Sc*, *CaW*, AW, LR, SK, BB, RW, GH
Tripura	Sc, H, AW, *GB*, SB, *CaW*, *GH*
Uttar Pradesh	*GB*, *GLH*, PH, SB, *Sc*, *CaW*, AW, RW, *GH*
West Bengal	GLH, Sc, H, Ecc, *GB*, MB, SB, *CaW*, AW, LR, SK, *GH*

NOTE : Insect pests reported serious are italisized. Insect pests reported serious by States are shown in thick type.

APPENDIX 49.13—(Concld.)

(Paragraph 49·3·12)

II. Serious and Moderate Diseases of Paddy Crop

State	Information from States and from literature
Andhra Pradesh	**Bla**, *FR*, ***He***, TV
Assam	*FR*, *He*, *Bla*, TV
Bihar	FR, *He*, *Bla*, *BLB*, *TV*
Gujarat	*He*, *Bla*, TV
Haryana	*He*, *Bla*, TV
Himachal Pradesh	*FR*, *He*, *Bla*, TV
Jammu & Kashmir	*He*, *Bla*, *BLB*, TV
Karnataka	*FR*, *He*, *Bla*, TV
Kerala	*He*, *Bla*, TV
Madhya Pradesh	*FR*, ***He***, *Bla*, *BLB*, TV
Maharashtra	*He*, *Bla*, *BLB*, TV
Manipur	*He*, *Bla*, TV
Orissa	SR, RR, *FR*, *He*, *Bla*, *BLB*, *TV*
Punjab	*He*, *Bla*, TV
Rajasthan	*He*, *Bla*, TV
Tamil Nadu	FR, He, Bla, TV
Tripura	*FR*, *He*, *Bla*, TV
Uttar Pradesh	*FR*, *He*, *Bla*, *BLB*, *TV*
West Bengal	**BLB**, *FR*, *He*, *Bla*, TV

NOTE: Diseases reported serious are italicized. Diseases reported selrous by States are shown in thick type.

APPENDIX 49.14

(Paragraph 49.3.12)

I. Serious and Moderate Insect Pests of Jowar, Maize, Bajra and Lesser Millets Crops

State	Information from State and from literature
Andhra Pradesh	EhB1, Ap, ***SB***, ***EhW*c1**, PB, AW, *LC*, ***RHC***, ***BHC***, SF, *DWGH*, *GH*
Assam	Ap, ***SB***, PB
Bihar	Ap, ***SB***, PB, AW, CW, ***RHC***, ***GH***
Gujarat	***RHC***, *M*1, ***DWGH***
Haryana	Ap, ***SB***, SF
Himachal Pradesh	CW, WG, *GH*
Jammu & Kashmir	**SB2**, **CW2**
Karnataka	RHC, EhB1, RAp, *SB*, ***EhW*c1**, AW, LC, *BHC*, WB, SF, GH, *DWGH*
Kerala	***BHC***
Madhya Pradesh	EhB1, Ap, ***SB***, AW, LC, ***RHC***, ***DWGH***, CW
Maharashtra	**HC1**, **M1**, **DWGH1**, 3, EhB1, Ap, ***SB***, AW, ***RHC***, SF, *M*1
Manipur	
Orissa	Ap, ***SB***, CW, ***RHC***, WB, GH
Punjab	Ap, *SB*, CW, LC, ***RHC***, SF, WG, ***GH***
Rajasthan	**SB2**, RHC, *SB*, AW, CW, ***RHC***, ***GH***
Tamil Nadu	EhB1, RAp, ***SB***, PB, AW, LC, ***RHC***, ***BHC***, WB, SF, *DWHG*, *GH*
Tripura	
Uttar Pradesh	Ap, ***SB***, CW, ***RHC***, WG, ***GH***
West Bengal	***SB***, CW

NOTE : 1. only for jowar. 2. only for maize. 3. only for bajra.
Insect pests reported serious are italicised. Insects reported serious by States are shown in thick type. No number on the side of insect pests means for all the crops.

APPENDIX 49.14 (Concld.)

(Paragraph 49.3.12)

II. Serious and Moderate Diseases of Jowar, Maize, Bajra and Lesser Mlliets Crops

State	Information from States and from literature
Andhra Pradesh	*GS1, LS1, DM1₂*, BLB2, *GED3*, S3, He4, *S4*
Assam	*GS1, LS1*, BLB2, DM2, *GED3*, S3, He4
Bihar	*GS1, LS1*, BLB2, *DM2*, *GED3*, S3, He4
Gujarat	*GS1, LS1*, *BLB2*, *DM2*, *GED3*, *S3*, He4
Haryana	*GS1, LS1*, An1, Le S1, BLB2, *DM2*, *GED3*, S3, Er3, He4
Himachal Pradesh	*GS1, LS1*, An1, Le S1, BLB2, *DM2*, *GED3*, S3, He4
Jammu & Kashmir	*GS1, LS1*, An1, Le S1, BLB2, *DM2*, *GED3*, S3, He4,
Karnataka	*GS1, LS1, DM1₂*, BLB2, *GED3*, S3, S4, Er3, He4
Kerala	*GS1, LS1*, BLB2, *DM2*, *GED3*, S3, He4
Madhya Pradesh	*GS1, LS1, DM1₂*, An1, Le S1, BLB2, *GED3*, S3, S4, He4
Maharashtra	SuD1, *GS1, LS1, DM1₂*, BLB2, *GED3*, S3, *S4*, Er3, He4
Manipur	BLB2, *DM2*
Orissa	*GS1, LS1*, BLB2, *DM2*, *GED3*, S3, He4
Punjab	*GS1*, He4, *LS1*, An 1, Le S1, BLB2, *DM2*, *GED3*, S3
Rajasthan	*GS1, LS1*, An1, Le S1, BLB2, DM2, *GED3*, S3, Er 3, He4
Tamil Nadu	*GS1, LS1, DM1₂*, BLB2, *GED3*, S3, *S4*, Er3, He4
Tripura	
Uttar Pradesh	*GS1, LS1*, BLB2, *DM2*, *GED3*, S3, Er3, He4
West Bengal	*GS1, LS1*, An1, Le S1, BLB2, *DM2*, *GED3*, S3, He4.

NOTE : 1. only for jowar 2. only for maize 3. only for bajra 4. only for lesser millets
Diseases reported serious are italicised. Diseases reported serious by States are shown in thick type. No number on the side of diseases means for all the crops.

APPENDIX 49·15

(Paragraph 49.3.12)

I. Serious and Moderate Insect Pests of Wheat, Barley and Oats crops

State	Information from States and from literature
Andhra Pradesh	Ap
Assam	Ap
Bihar	**CW1**, *Ap*, *Te*, *AW*, Ec
Gujarat	Ap
Haryana	Ap, Cw, *Te*, TW, W
Himachal Pradesh	Ap, CW
Jammu & Kashmir	Ap
Karnataka	Ap
Kerala	
Madhya Pradesh	Ap, *Te*, PB, CW, GH
Maharashtra	Ap, PB
Manipur	
Orissa	Ap, PB
Punjab	Ap, *Te*, CW, AW, W, GH, *Ec*, RKE
Rajasthan	**BB1**, Ap, *Te*, CW, AW, W, *Ec*, RKE
Tamil Nadu	Ap
Tripura	Ap1
Uttar Pradesh	Ap, *Te*, AW, W, *Ec*
West Bengal	Ap, *Te*, W

NOTE : 1 only for wheat crop.

Insect pests reported serious are italicised. Insect pests reported serious by States are shown in thick type. No number on the side of insect pests means for all the crops.

APPENDIX 49·15— (Concld)

(Paragraph 49·3·12)

II. Serious and Moderate Diseases of Wheat, Barley and Oats crops

State	Information from States and from literature
Andhra Pradesh	*BR*, Br R1,2, *YR*2, LS1,2, *CS*2,*3*, YR1
Assam	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Bihar	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, *St D*2
Gujarat	*BR* Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Haryana	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Himachal Pradesh	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, Bul
Jammu & Kashmir	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, Bul
Karnataka	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Kerala	
Madhya Pradesh	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2 .
Maharashtra	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, *St D*2
Manipur	
Orissa	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Punjab	*YR*2, *BR*, Br R1, YR1, LS1, 2, Ye R1, Bul, Mo1, FS1, *CS*2, *3* KBul
Rajasthan	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, Ye R1, Mo1, FS1, *St D*2
Tamil Nadu	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2
Tripura	
Uttar Pradesh	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, Ye R1, Bul, KBul, FS1, *St D*2.
West Bengal	*BR*, Br R1, YR1, LS1,2, *CS*2,*3*, *YR*2, *St D*2

NOTE: Diseases reported serious are italicised.

1. only for wheat. 2. only for barley. 3. only for oats.

No number on the side of diseases means for all the crops.

APPENDIX 49.16

(Paragraph 49·3·12)

I. Serious and Moderate Insect Pests of Cotton Crop

State	Information from States and from literature
Andhra Pradesh	Ja, RCB, Ap, DaCB, Th, *PBW*, *SBW*, *LR*, *SB*, Mi, SW
Assam	Ja, RCB, Ap, DaCB, *PBW*, *SBW*, LR, GrW, SW
Bihar	Ja, RCB, WF, DaCB, *PBW*, *SBW*, LR, GrW, SW
Gujarat	Ja, Ap, DaCB, *PBW*, *SBW*, LR, GrW, Mi
Haryana	**Ja, RCB, S1, WF, Ap, LR, Mi, DaCB, PBW, SBW, HC, GrW**
Himachal Pradesh	
Jammu & Kashmir	
Karnataka	PBW, Ja, RCB, Ap, DaCB, Th, *PBW*, LR, SW; *SB*, Mi
Kerala	Ap, DaCB, *PBW*, *SBW*
Madhya Pradesh	Ja, RCB, AP, DaCB, *PBW* *SBW*, GrW, *SB*, Mi, L
Maharashtra	GW, Fcr, Ja, RCB, WF, Ap, DaCB, Th, *PBW*, *SBW*, GrW, *SB*, GH, Mi
Manipur	
Orissa	Ja, RCB, Ap, DaCB, *PBW*, *SBW*, LR, GrW, SW, GH
Punjab	Ja, RCB, *WF*, Ap, DaCB, *PBW*, *SBW*, LR, GrW, *SB*, GH, Mi, Th
Rajasthan	**Ja, S1, WF, Ap, Fcr**, Sb, RCB, DaCB, *PBW*, *SBW*, LR GrW, SW, Mi
Tamil Nadu	Ja, RCB, Ap, DaCB, Th, *PBW*, *SBW*, LR, SW, *SB* Mi
Tripura	*SBW*, LR
Uttar Pradesh	Ja, RCB, Ap, DaCB, *PBW*, *SBW*, LR, GrW, GH
West Bengal	Ja, RCB, Ap, DaCB, *SBW*, LR

NOTE : Insect pests reported serious are italicised. Insects pests reported serious by states are shown in thick type.

APPENDIX 49.16—(Concld.)

(Paragraph 49.3.12)

II. Serious and Moderate Diseases of Cotton Crop

State	Information from States and from literature
Andhra Pradesh	*Wi*, RR, *An*
Assam	*Wi*, RR
Bihar	*Wi*, RR, *An*
Gujarat	*Wi*, RR, *BA*
Haryana	*Wi*, RR, Ti
Himachal Pradesh	*Wi*, RR, Ti
Jammu & Kashmir	*Wi*, RR, Ti
Karnataka	*Wi*, RR, *BA*
Kerala	*Wi*, RR, *BA*
Madhya Pradesh	*Wi*, RR, *An*, Ti
Maharashtra	*Wi*, RR, *Gr M*, ALLS
Manipur	
Orissa	*Wi*, RR
Punjab	*Wi*, RR, Ti
Rajasthan	BA, *Wi*, RR
Tamil Nadu	*Wi*, RR, *An*, *BA*
Tripura	*Wi*, RR
Uttar Pradesh	*Wi*, RR, Ti
West Bengal	*Wi*, RR, *An*, Ti

NOTE : Disease reported serious are italicised. Diseases reported Serious by states are shown in thick type.

APPENDIX 49.17

(Paragraph 49.3.12)

I. Serious and Moderate Insect Pests of Jute and Sugarcane Crops

State	Information from States and from literature
Andhra Pradesh	*Py*, WF, MB, Te, SB, *TB*, Mi
Assam	*Sl*,1, Bi HCl, *SW* 1, *Cr* 1, Py MB, Te, SB, *TB*, *Mi* 1
Bihar	**Py**, **TB**, *Sl* 1, Bi HCl, SG1, *Cr*1, Mi, WF, BaB, MB, Th, Te, SB, PB, RB, GH, *Mi* 1
Gujarat	*Py*, WF, Te, SB, *TB*
Haryana	**Py**, Te, SB, *TB*, Mi, GH
Himachal Pradesh	*Py*, WF, Te, *TB*
Jammu & Kashmir	*Py*, Te, *TB*
Karnataka	*Py*, MB, Te SB, PB, RB, *TB*, GH
Kerala	Py, Te, *TB*
Madhya Pradesh	*Py*, WF, Te, SB, PB, RB, *TB*, GH
Maharashtra	Py, WF, MB, Te, SB, *TB*, GH
Manipur	*Py*, Te, *TB*
Orissa	Sl, 1, *TB*, Bi, HCl, *SW* 1, SG 1, *Mi* 1, *Py*, WF, Te, SB, PB, RB
Punjab	GH, *Py*, WF, BaB, MB, Te, *SB*, PB, RB, *TB*, Mi
Rajasthan	Py, Te, SB, *TB*
Tamil Nadu	*Py*, WF, MB, Th, Te, SB, PB, RB, *TB*, Mi, GH
Tripura	*Sl*, 1, *Py*, Te, SB, *TB*
Uttar Pradesh	Bi HCl, SG 1, Mi, *Sl* 1, *Py*, WF, BaB, MB, Te, *SB*, PB, RB, *TB*, GH, *Mi* 1.
West Bengal	SG1, PB, SB, RB, *Cr*1, *Mi*1, *T B*, *MB* 1, Sca 1, *Sl* 1, BiHCl, *SW* 1, *Py*, WF, Te.

NOTE : Insect pests reported serious are italicised. Insects pests reported serious by States are shown in thick type.

1. Only for jute. Rest for sugarcane.

APPENDIX 49.17—(Conc'd.)

(Paragraph 49.3.12)

II. Serious and Moderate Diseases of Jute and Sugarcane Crops

State	Information from States and from literature
Andhra Pradesh	*ReR*, *S*, *R*, V
Assam	*RRl*, *ReR*, *S*
Bihar	*ReR*, *S*; V
Gujarat	*ReR*, *S*
Haryana	*ReR*, *S*
Himachal Pradesh	*ReR*, *S*
Jammu & Kashmir	*ReR*, *S*
Karnataka	*ReR*, *S*
Kerala	*ReR*, *S*
Madhya Pradesh	*ReR*, *S*
Maharashtra	*ReR*, *S*, R, V
Manipur	
Orissa	*RR*1, ReR, S
Punjab	*ReR*, *S*
Rajasthan	*ReR*, *S*
Tamil Nadu	*ReR*, *S*, R, SR, V
Tripura	*RRl*, *ReR*, *S*
Uttar Pradesh	*ReR*, *S*, R, V
West Bengal	*RRl*, *ReR*, *S*

NOTE : Diseases reported serious are italicised.
1. only for jute. Rest for sugarcane.

APPENDIX 49·18

(Paragraph 49·3·12)

I. Serious and Moderate Pests of Pulses
(Black and Green gram, Gram, Pigeon Pea, Pea)

State	Information from States and from literature
Andhra Pradesh . .	**PoB**, GC, CW, ***RHC***
Assam	GC, CW, ***RHC***, Sl, ***BiHC***, ***SB***
Bihar	**CW**, **PoB**, GC, CW, ***RHC***, Sl, ***BiHC***, LM, PF
Gujarat	GC, ***RHC***
Haryana	
Himachal Pradesh . .	CW, ***RHC***
Jammu & Kashmir	
Karnataka . . .	**PF**, GC, CW, ***RHC***, ***BiHC***
Kerala	
Madhya Pradesh . .	GC, CW, *RHC*, Sl, LM; PF
Maharashtra . . .	GC, CW, *RHC*, PF
Manipur	
Orissa	CW (Moong), GC, CW, ***RHC***; LM, PF
Punjab	GC, CW, *RHC*, *BiHC*, LM
Rajasthan . . .	GC, CW, *RHC*
Tamil Nadu . . .	*RHC*, CW
Tripura	
Uttar Pradesh . . .	GC, CW, *RHC*, Sl, LM, PF
West Bengal . . .	GC, CW, LM, PF,

NOTE : Insect pests reported serious are italicised. **Insect pests reported serious by States are in thick type.**

APPENDIX 49·18—(Concld.)

(Paragraph 49·3·12)

II. Serious and Moderate Diseases of Pulses (Black and Greengram, Gram, Pigeon Pea, Pea)

State	Information from States and from literature
Andhra Pradesh . .	*Wi*2,3, *PM*4
Assam	Le S1, *Wi*2,3, *PM*4
Bihar	Le S1, *Wi*2,3, *PM*4, Wi4
Gujarat	*Wi*2,3, *PM*4
Haryana	*Wi*2,3, *BLB*2, *PM*4, Wi4
Himachal Pradesh . .	*Wi*2,3, *PM*4, Wi4
Jammu & Kashmir . .	Le S1, *Wi*2,3, BLB2, PM4, Wi4
Karnataka . . .	*Wi*2, 3, *PM*4
Kerala	*Wi*2, 3, *PM*4
Madhya Pradesh . .	Le S1, *Wi*2,3, *PM*4
Maharashtra . . .	Le S1, *Wi*2,3, *PM*4
Manipur	
Orissa	*Wi*2,3, *PM*4
Punjab	*Wi*2,3, *PM*4, Wi4, *BLB*2
Rajasthan . . .	*Wi*2,3, *PM*4, Wi4
Tamil Nadu . . .	Le S1, *Wi*2,3, *PM*4
Tripura	*Wi*2,3, *PM*4
Uttar Pradesh . . .	Le S1, *Wi*2,3, *PM*4
West Bengal . . .	*Wi*2,3, PM4, Wi4

NOTE : Diseases reported serious are italicised.
1. only for black and green gram. 2. only for gram. 3. only for pigeon pea. 4. only for pea.

APPENDIX 49·19

(Paragraph 49.3·12)

I. Serious and Moderate Insect Pests of Oilseeds (Groundnut, Mustard, Castor, Til and Linseed)

State	Information from States and from literature
Andhra Pradesh	LM1, Ap1, Pa B2, *RHCl*, *Ap*2, GM5, WF3, *Sl*3, S&CB3, HC3, *L&PC*4
Assam	*Ap*2, PaB2, BtF2, FlB2, SaF2, S&CB3, *L&PC*4, *HM*4
Bihar	*Ap*2, PaB2, GM5, WF3, S13, *L&PC*4, SaF2
Gujarat	PaB2, *HM*4, *Ap*2, *L&PC*4, GF4, Apl, *RHCl*
Haryana	Ap2, PaB2, BuF2, FlB2, SaF2, HC3
Himachal Pradesh	*Ap*2, PaB2, BuF2, FlB2
Jammu and Kashmir	*Ap*2, PaB2
Karnataka	RCH[1], *Ap*2, PaB2, LM1, Apl, SaF2, S13, S&CB3, HC3, *L&PC*4
Kerala	*L&PC*4, *HM*4, GF4
Madhya Pradesh	Apl, *Ap*2, *RHCl*, PaB2, SaF2, S13, S&CB3, HC3, *L&PC*4, *HM*4, GF4, GM5
Maharashtra	Fcrl, *Ap*2, PaB2, *RHC*1, Apl, SaF2, WF3, S13, S&CB3, *L&PC*4, *HM*4, GF4
Manipur	*Ap*2, PaB2
Orissa	*L&PC*4, HC3, HM4, *Ap*2, PaB2, BtF2, FlB2, S13, S&CB3
Punjab	*RHC*l, GM5, HC3, *Ap*2, PaB2, BuF2, FlB2, SaF2, WF3, S13
Rajasthan	**Fcrl**, *Ap*2, PaB2, *L&PC*4, *HM*4, **RHC1**, **Th4**
Tamil Nadu	Apl, *Ap*2, *RHC*l, LM1, PaB2, BuF2, SaF2, WF3, S13, S&CB3, HC3, *L&PC*4, GF4, FlB2
Tripura	*Ap*2, PaB2
Uttar Pradesh	*RHC*l, *Ap*2, PaB2, BuF2, FlB2, SaF2, S13, S&CB3, HC3, TC3, *L&PC*4, *HM*4, GM5
West Bengal	*L&PC*4, *Ap*2, PaB2, BuF2, FlB2, SaF2, S&CB3

NOTE : Insect pests reported serious are italicised. Insect pests reported serious by States are in thick type.

1. only for groundnut. 2. only for mustard. 3. only for castor. 4. only for til. 5. only for linseed.

APPENDIX 49·19 (Concld.)

(Paragraph 49·3·12)

II. Serious and Moderate Diseases of Oilseeds (Groundnut, Mustard, Castor, Til and Linseed)

State	Information from States and from literature
Andhra Pradesh . .	*TiKl*, *Vl4*, *BuR*1, PoBl2, DM2, WR2, *R*35, Wi5, BLB4, Le S4
Assam	PoBl2, DM2, WR2, *R5*, Wi5, *BLB*4.
Bihar	TiKl, *V*l, PoBl2, DM2, WR2, *R5*, Wi5, RR2,
Gujarat	TiKl, *V*l, PoBl2, DM2, WR2, *PhB*4, BLB4, Le, S4
Haryana	TiKl, *V*l, PoBl2, DM2, WR2, *R5*, Wi5
Himachal Pradesh . .	TiKl, *V*l, PoBl2, DM2, WR2, *R5*, Wi5
Jammu & Kashmir . .	PoBl2, DM2, WR2, *R5*, Wi5
Karnataka . . .	TiKl, *V*l, *BuR*1, PoBl2, DM2, WR2, *R5*, Wi5
Kerala	TiKl, *V*l, *BuR*1
Madhya Pradesh . .	TiKl, *V*l, AlB3, PoBl2, DM2, WR2, BLB4, LeS4, *R5*, Wi5
Maharashtra . . .	TiKl, *V*l, PoBl2, DM2, WR2, R35, Wi5, AlB3
Manipur	PoBl2, DM2, WR2
Orissa	TiKl, *V*l, PoBl2, DM2, WR2, *R5*, Wi5
Punjab	TiKl, *V*l, PoBl2, DM2, WR2, RR2, *R5*, Wi5
Rajasthan . . .	BLB4, LeS4, Ph B4, TiKl, *V*l, *R5*, PoBl2, DM2, WR2, Wi5
Tamil Nadu . . .	TiKl, *V*l4, *BuR*1, *R*3, PoBl2, DM2, WR2, BLB4, LeS4
Tripura	
Uttar Pradesh . . .	TiKl, *V*l4, AlB3, PoBl2, DM2, WR2, RR2, BLB4, Le S4, *R5*, Wi5
West Bengal . . .	PoBl2, DM2, WR2, RR2

NOTE : Diseases reported serious are italicised. Diseases reported serious by States are in thick type.

1. only for groundnut. 2. only for mustard. 3. only for castor. 4. only for til. 5. only for linseed.

APPENDIX 49·20

(Paragraph 49·3·12)

I. Serious and Moderate Insect Pests of Plantation Crops

State	Information from States and from literature
Andhra Pradesh	*MoS*3, *Th*3, Sca 6,7, BHaC6, SluC6, *RhB*6, RpW6, *BeB*8
Assam	*MOS*1, L1, *RSlu*1, Te1, *BW*1, *Ne*1, RS1, *RhB*6, RpW6
Bihar	
Gujarat	
Haryana	
Himachal Pradesh	
Jammu & Kashmir	
Karnataka	*MOS*1, L1, Te1, RS1, *GrB*2, *ReB*2, Cw2, SHB2, MB7,8 *RMi*1, *BeB*8, SB2, ReBo2, GH2, Slu16, Te6, SpB7, Sca7, *RhB*6, RpW6
Kerala	CW2, SHB2, Sluc6, *RhB*6, RPW6, COB6, Te6. SpB7, MB7, *RMi*7, SB2, ReBo2, GH2, *Th*3,5, LeC3, LM3, *CB*3, *Sca*6,7, BHaC6, L1, Te1, RS1, *GrB*2, *ReB*2
Madhya Pradesh	*BeB*8, MB8
Maharashtra	SluC6, *RhB*6, RPW6, COB6, Te6, *BeB*8, MB8
Manipur	
Orissa	*MOS*3, *Th*3, BHaC6, *RhB*6, RPW6, *BeB*8
Punjab	
Rajasthan	
Tamil Nadu	COB6, RPW6, *MOS*1,3, L1, Te1, Ne1, RS1, *GrB*2, *ReB*2, CW2, SHB2, *BeB*8, Slic6, MB8, *RhB*6, SB2, ReBo2, GH2, *Th*3, LeC3, LM3, Sca6, BHaC6
Tripura	
Uttar Pradesh	*BeB*8, *MB*8
West Bengal	*MOS*1, *RSlu*1, *Ne*1, RS1, BHaC6, *RhB*6

NOTE : Insect pests reported serious are italicised.

1. only for tea. 2. only for coffee. 3. only for cashewnut. 4. only for rubber. 5. only for cocoa. 6. only for coconut. 7. only for arecanut. 8. only for betelvine.

APPENDIX 49.20 (Concld.)

(Paragraph 49.3.12)

II. Serious and Moderate Diseases of Plantation Crops

State	Information from States and from literature
Andhra Pradesh . .	NuF6, *Wi*8
Assam	*BB*11, NuF6, *FrR*7, FR7, *Wi*8
Bihar	*Wi*8
Gujarat	*Wi*8
Haryana	*Wi*8
Himachal Pradesh . .	*Wi*8
Jammu & Kashmir . .	*Wi*8
Karnataka . . .	*BB*11, R2, BaR2, DB2, *DO*2, BrRo2, NuF6, *FrR*7, FR7, *StB*7, *Wi*8
Kerala	*BrB*1,1, *Gr B*11, BrRR1, *ChS*1, *ReRR*1, R2, BaR2, DO2, *BrRo*2, *BLB*4, *PM*4, MR4, NuF6, *LeR*6, *V*6, *FrR*7, FR7, *Wi*8
Madhya Pradesh . .	*Wi*8
Maharashtra . . .	NuF6, *FrR*7, *Wi*8
Manipur	
Orissa	NuF6, *Wi*8
Punjab	*Wi*8
Rajasthan . . .	*Wi*8
Tamil Nadu . . .	*BB*11, R2, BaR2, DB2, *DO*2, *BrRo*2, NuF6, *StB*7, *Wi*8
Tripura	
Uttar Pradesh . . .	*Wi*8
West Bengal . . .	BBii, NuF6, FR7, *Wi*8

NOTE : Diseases reported serious are italicised.

1. only for tea.
2. only for coffee.
3. only for cashewnut.
4. only for rubber.
5. only for cocoa.
6. only for coconut.
7. only for arecanut.
8. only for betelvine.

APPENDIX 49.21

(Paragraph 49.3.12)

I. Serious and Moderate Insect Pests of Tobacco, Pepper, Turmeric, Ginger, Cumin, Coriander, Cardamom and Chilli Crops

State	Information from States and from literature
Andhra Pradesh	*GPAp1*, WF1, CW1, *LC*1, SL1, SB1, TC1, Th3, *SK3,4*, GBO4 FHB5,6, Ap5,6, LC5,6.
Assam	SB1, TC1
Bihar	WF1, SB1, TC1, BiHC3
Gujarat	SB1, TC1, GBO4, *SK4*, FHB5,6, Ap5,6, LC5,6
Haryana	SB1, TC1
Himachal Pradesh	SB1, TC1
Jammu & Kashmir	SB1, TC1
Karnataka	GPAp1, *LC1*, SL1, SB1,3, TC1, *Sca*2, MB2, F1B2, LWB3, Th3, GBO4, SK4, FHB5,6, Ap5,6, LC5,6, *Th7*, Le EC7
Kerala	*Sca*2, *MB*2, F1B2, LwB3, Th3, SB3, GBO4, *SK4*, FHB5,6, Ap5,6, LC5,6, *Th7*, LeEC7, SB1, TC1,
Madhya Pradesh	CW1, SB1, TC1
Maharashtra	WF1, CW1, SB1, TC1, *SK3,4*, GBO4, FHB5,6, Ap5,6, LC5,6,
Manipur	SB1, TC1
Orissa	*GPAp1*, SB1, TC1, *Sca3*, *SK3,4*, *LB*3, GBO4
Punjab	SB1, TC1, *SK*3
Rajasthan	SB1, TC1
Tamil Nadu	GPAp1, CW1, LC1, S11, SB1, TC1, *SK3,4*, GBO4, FHB5,6, Ap5,6, LC5,6, *Th7*, LeEC7
Tripura	SB1, TC1
Uttar Pradesh	CW1, SB1, TC1
West Bengal	SB1, TC1, BiHC3

NOTE : Insects pests reported serious are italicised.

1. only for tobacco
2. only for pepper
3. only for turmeric
4. only for ginger.
5. only for cumin
6. only for coriander
7. only for cardamom
8. only for chilli (Spices).

APPENDIX 49.21 (Concld.)

(Paragraph 49.3.12)

II. Serious and Moderate Diseases of Tobacco, Pepper, Turmeric, Ginger, Cumin, Coriander, Cardamom and Chilli crops

State	Information from States and from literature
Andhra Pradesh	*DO1*, LeS1,3, *V1*, Ap1, *PM1*, RhiR4, *DB8*, V8
Assam	*DO1*, LeS1, RhiR4, LeB3, GD6, DB8, V8
Bihar	*DO1*, LeS1,4, LeB3, GD6, *DB8*, DO8, V8
Gujarat	*DO1*, LeS1, *PM5*, Wi5, *DB8*, V8
Haryana	*DO1*, LeS1, *DB8*, V8
Himachal Pradesh	*DO1*, LeS1, *DB8*, V8
Jammu & Kashmir	*DO1*, LeS1, *DB8*, V8
Karnataka	*DO1*, LeS1,3, *PM1,8*, *Wi2*, RhiR4, V7, *DB8*, V8
Kerala	*DO1*, LeS1, *V1,7*, *Wi2*, *DB8*, RhiR4, V8, *Po2*
Madhya Pradesh	*DO1*, LeS1,3,4, *PM5*, GD6, *DB8*, DO8, V8
Maharashtra	*DO1*, LeS1,3,4, LeB3, *PM5*, A1B5, *V7*, *DB8*, DO8, V8
Manipur	DO1, LeS1
Orissa	*DO1*, LeS1,4, DB8, *DO8*, V8
Punjab	*DO1*, LeS1, GD6, *DB*8, DO*8*, V8
Rajasthan	*DO1*, LeS1,4, *PM5*, *Wi5*, A1B5, *DB8*, DO8, V8
Tamil Nadu	*DO1*, LeS1,3, RhiR4, *V7*, *DB*8, *DO8*, V8
Tripura	*DC1*, LeS1
Uttar Pradesh	*DC1*, LeS1,4, LeB3, GD6, DB8, DO8, V8
West Bengal	DO1, LeS13, RhiR4, LeB3, GD6, *V7*, *DB8*, DO8, V8

NOTE : Diseases reported serious are italicised.

1. only for tobacco
2. only for pepper
3. only for turmeric
4. only for ginger
5. only for cumin
6. only for coriander
7. only for cardamom
8. only for chilli(spices)

APPENDIX 49.22

(Paragraph 49.3.12)

I(a). Serious and Moderate Insect Pests of Mango, Apple, Banana, Grapes and Citrus Crops

State	Information from States and from literature
Andhra Pradesh	*HO1*, *MB1*, BEC1,5, FrF1, *SB1*, RA1, Te1, *SUS2*, W3, Sca4, Th4, *FIB4*, *Ch4*, GiB4
Assam	*HO1*, *MB1*, FrF1,5, *SB1*, Te1, *SJS2*, *WAp2*, RB2, W3
Bihar	*HO1*, *MB1*, Sca1, Ps1, BEC1, 5, FrF1 F1, RA1 Te1, W3
Gujarat	*HO1*, *MB1*, FrF1, Te1, W3
Haryana	*HO1*, *MB1*, Sca1, BEC1, 5, FrF1,5, RA1, Te1
Himachal Pradesh	*HO1*, FrF1, Te1, *SJS3*, *WAp2*, TeC2, RB2, SB2
Jammu & Kashmir	*SJS2*, *WAp2*, RB2, SB2
Karnataka	*HO1*, FrF1,5, *SB1*, Te1, *SJS2*, *WAp2*, W3, Sca4 Th4, *FLB4*, *Ch4*, GiB4
Kerala	*HO1*, BEC1,5, FrF1,5, *SB1*, RA1, Te1, W3
Madhya Pradesh	*HO1*, *MB1*, BEC1,5, FrF1,5, *SB1*, RA1, Te1, F1B4
Maharashtra	*HO1*, *MB1*, BEC1, FrF1,5, *SB1*, RA1, Te1, W3, Sca4, Th4, *FIB4*, *Ch4*, GiB4
Manipur	
Orissa	*HO1*, *MB1*, Sca1,4, BEC1,5, FrF1,5, LGF*1*, *SB1*, RA1, Te1, *SJS2*, W3
Punjab	*HO1*, *MB1*, Sca1,4, FrF1,5, RA1, Te1, *SJS2*, *WAp2*, TeC2, RB2, SB2, Th4, *Ch4*
Rajasthan	*HO1*, BEC1, FrF1, RA1, Te1
Tamil Nadu	*HO1*, *MB*1, BEC1,5, FrF1,5, Te1, *SJS2*, *WAp2*, W3, Sca4
Tripura	*HO1*, FrF1, Te1
Uttar Pradesh	*HO1*, MB1, Sca1, Ps1, BEC1,5, FrF1,5, LGF1, RA1, Te1, *SJS2*, *WAp2*, TeC2, RB2, W3, Th4, SB2
West Bengal	*HO1*, *MB1*, FrF1,5, Te1, *SJS2*, W3

NOTE : Insect pests reported serious are italicised.

1. only for mango
2. only for apple
3. only for banana
4. only for grapes
5. only for citrus

APPENDIX 49.22 (Contd.)

(Paragraph 49.3.12)

I(b) Serious and Moderate Insect Pests of Mango, Apple Banana, Grapes and Citrus Crops

State	Information from States and from literature
Andhra Pradesh . .	Ps5, WF5, FluS5, ReS5, *BuF5*, *FSM5*, LM5
Assam	WF5, GrB5, *BuF5*, *FSM5*, LM5, OBB5
Bihar	Ps5, WF5, *BuF5*, *FSM5*, LM5, OBB5
Gujarat	*BuF5*, LM5
Haryana	Ps5, BuF5, *FSM5*, LM5
Himachal Pradesh . .	Ps5, ReS5, BuF5, LM5
Jammu & Kashmir . .	
Karnataka . . .	WF5, FluS5, BuF5, LM5, TSB5, SB5, OBB5
Kerala . . .	FluS5, BuF5, *FSM5*, LM5, SB5
Madhya Pradesh . .	*Ch4*, FluS5, BuF5, *FSM5*, LM5, WF5, OBB5
Maharashtra . . .	Ps5, WF5, *BuF5*, *FSM5*, LM5, OBB5
Manipur . . .	
Orissa	Th4, ReS5, *FSM5*, *BuF5*, LM5
Punjab	*BuF5*, BEC5, LM5, *FlB4*, OBB5, GiB4, *Ps5*, WF5, ReS5, *FSM5*
Rajasthan . . .	BuF5, Ps5, LM5
Tamil Nadu . . .	Th4, *FlB4*, *Ch4*, Ps5, WF5, FluS5, *BuF5* *FSM5*, LM5, TSB5, SB5, *Mi5*
Tripura	Ps5, GrB5, BuF5, LM5
Uttar Pradesh . . .	Ps5, WF5, BuF5, *FSM5*, *LM5*, OBB5
West Bengal . . .	GrB5, BuF5, M5, OBB5

NOTE : Insect pests reported serious are italicized. Insects pests reported serious by States are in thick type.

1. only for mango
2. only for apple
3. only for banana
4. only for grapes
5. only for citrus

APPENDIX 49.22 (Concld.)

(Paragraph 49.3.12)

II Serious and Moderate Diseases of Mango, Apple, Banana, Grapes and Citrus Crops

State	Information from States and from literature
Andhra Pradesh . .	*PM1,4*, *PD1*, Mal 1, Wl3, An3, 4, *DM4* *Ca5*, *WT5*, *LeF5*, *Gu5*, PM5, Zn5, *DB5*
Assam	Anl, Mal 1, BiR2, Wi3, V3, *Si3*, An3, 4, *Ca5*, *WT5*, *Gu5*, Zn5, *DB5*
Bihar	*BT1*, Mal 1, Wi3, An3,4, *Ca5*, *WT5*, Zn5, *DB5*
Gujarat	*PM1*, Mal 1, An3, *Ca5*, *WT5*, Zn5, Gu5, *DB5*
Haryana	Mal, 1, *Ca5*, *WT5*, Zn5, *DB5*
Himachal Pradesh . .	Mal 1, *SBa2*, *SBr2*, *PM2*, SB&F2, *Ca5*, *WT5*, Zn5 *DB5*
Jammu & Kashmi . .	Mal 1, *SB2*, *PM2*, SB&F2, *Ca5*, *WT5*, Zn5, *DB5*
Karnataka . . .	*PM1, 2,4*, Mal 1, An3, *DM4*, *Ca5*, *WT5*, *LeF5* *PM5*, Zn5, *DB5*
Kerala	*PM1*, Anl,3,4, *PD1*, Mal 1, Wi3, V3, *Ca5*, *WT5*, PM5 Zn5, *DB5*
Madhya Pradesh . .	*PM1*, Mal 1, Wi3, An3, 4, *Ca5*, *WT5*, *Gu5*, Zn5, *DB5*
Maharashtra . . .	Mal 1, An3, *PM4*, *DM4*, *Ca5*, *WT5*, *Gu5*, *Zn5*, *DB5*
Manipur	
Orissa	Mal 1, V3, An3, *Ca5*, *WT5*, *Zn5*, *DB5*
Punjab	*BT1*, Aml, Mal 1, *Sb2*, *PM2*, *LeS2*, SB&F2, *BrRO 2*, Ca5, *WT5*, *DB5*, Zn5
Rajasthan	Mal 1, *Ca5*, *WT5*, Zn5, *DB5*
Tamil Nadu . . .	*PM1*, 4, Anl,3,4, *PD1*, Mal 1, Wi3, V3, *Si3*, *DM4*, *Ca5*, *WT5*, *LeF5*, *Gu5*, Zn5, *DB5*, Pm5
Tripura	Mal 1, *Ca5*, *Wt5*, Zn5, *DB5*,
Uttar Pradesh . . .	*BT1*, Anl,3, Mal 1, *SBa2* *SBr2*, *PD2*, *PM2*, *CR2*, *LeS2*, SB&F2, *Ca5*, *WT5*, Zn5, *DB5*
West Bengal . . .	*BT1*, Mal 1, *LeS2*, Wl3, V3, An3, 4, *Ca5*, *WT5*, Zn5, *DB5*

NOTE : Diseases reported serious are italicised.

1 Only for mango
2 ,, ,, apple
3 ,, ,, banana
4 ,, ,, grapes
5 ,, ,, citrus

APPENDIX 49.23

(Paragraph 49.3.12)

I(a) Serious and Moderate Insect Pests of Vegetables Crops

State	Information from States and from literature
Andhra Pradesh	W1, TBe1, Ap2, 3, CW2, MB3, Ja3, Ep, *Be3*, Mi3
Assam	Ap2, *Ja2*, CW2, Ep. Be2, *EpBe3.*
Bihar	W1, TBe1, Ap2,3, *Ja*2, CW2, LWB3, MB3, *SB*3. *FSB3*, *EpBe3*, RGE3.
Gujarat	Ap2, CW2, *EpBe3.*
Haryana	Ap2. LWB3, Ja3, *SB3*, *FSB3*, *Ep Be3.*
Himachal Pradesh	Ap2, CW2, Ep Be2, WG2, E2, *Ep Be3.*
Jammu & Kashmir	Ap2.
Karnataka	W1, TBe 1, Ap, 2,3, *Ja2*, CW2, EpBe2, MB3, *Ep Be3*
Kerala	W1, TBe1 , MB3, *Ep Be3.*
Madhya Pradesh	W1, TBe1, Ap2,3, *Ja*2, CW2, LWB3, Ja3, *SB3*, *FSB3*.
Maharashtra	Ap2,3, *Ja*2, CW2, EpBe2, Ja3, *EpBe*3,
Manipur	Ap2.
Orissa	W1, TBe1, Ap2,3, Ja2, EpBe2, MB3, Mi3.
Punjab	Ap2,3, Ja2, CW2, EpBe2, LWB3, Ja3, *SB3*, FSB3, *EpPe*3.
Rajasthan	W1, TBe1, Ap2, CW2,LWB3, Ja3, *SB3*, FSB3, *EpBe3*,
Tamil Nadu	W1, TBe1, Ap2, *Ja2*, CW2, *EpBe2*, *GNe2*, MB3, Ja3, *EpBe3.*
Tripura	Ap2.
Uttar Pradesh	W1, TBe1, Ap2,3, Ja2, CW2, EpBe2, WG2, LWB3, MB3, Ja3, *SB3*, *FSB3*, *EpBe3*, RGE3.
West Bengal	*EpBe3*, *FSB3*, *Ja2*, CW2, EpBe2, *MoCR2*, LWB3, SB3.

NOTE : Insect pests reported serious are italicised.

1. only for sweet potato.
2. only for potato
3. only fof brinjal.

APPENDIX 49.23 (Contd.)

(Paragraph 49·3·12)

I(b) Serious and Moderate Insect Pests of Vegetables Crops

State	Information from States and from literature
Andhra Pradesh	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, SBW6, *BB BE6*, *RSMi6*.
Assam	*Ap4*, *DBM4*, Ap5, Pa B5, Sa F5, FlB5, Ja6, SBW6, *BB Be6*, *RS Mi6*, BuF4.
Bihar	*Ap4*, *DBM4*, Ap5, PaB5, *SaF5*, FlB5, RCB6 SBW6, *BB Be6*, *RSMi6*.
Gujarat	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6
Haryana	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, SBW6, *PsMi6*, BuF4.
Himachal Pradesh	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6, BuF4
Jammu & Kashmir	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6.
Karnataka	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6.
Kerala	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6.
Madhya Pradesh	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, RCB6, SBW6,
Maharashtra	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, SBW6.
Manipur	
Orissa	Ja6, SBW6, *Ap4*, *DBM4*, Ap5, PaB5, FlB5, SaF5, BuF4, RCB6, **BB Be6**, **RSMi6**
Punjab	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, SBW6, BuF4, **BB Be6**, **RSMi6**
Rajasthan	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, SBW6
Tamil Nadu	*Ap4*, *DBM4*, ApF5, PaB5, Sa5, FlB5, Ja6, BuF4, SBW6.
Tripura	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6
Uttar Pradesh	*Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, Ja6, RCB6, SBW6, *BB Be6*, *RSMi6*, BuF4
West Bengal	*RSMi6*, *Ap4*, *DBM4*, Ap5, PaB5, SaF5, FlB5, SBW6

NOTE : Insect pests reported serious are italicised. Insect pests reported serious by States are shown in thick type.

4. only for cabbage, cauliflower & knol khol.

5. only for turnip, raddish & other cruciferous vegetables.

6. only for lady's finger.

APPENDIX 49.23 IC (Contd.)

(Paragraph 49.3.12)

I(c) Serious and Moderate Insect Pests of Vegetable Crops

State	Information from States and from literature
Andhra Pradesh . .	Fr B7, *RKE7*, Ap8,12, PoB8, *Th9*, Th10, LM 11, TC 13, *Fr F 12*, *RP Be 12*, BB Be 12.
Assam	Fr B7, Ap8, Th10, LM 11, *Fr F 12*, *RP Be 12*, BB Be12.
Bihar	*RKE7*, Ap8, *Th9*, Th10, LM11, *St Bu 12*, *Fr F12*, *RP Be 12*, BB Be 12.
Gujarat	Ap8, LM11, *Fr F12*, *RP Be 12*, BB Be 12.
Harayana . . .	Fr B7, Ap8, PoB8, LM 11, *St Bu 12*, *Fr F 12*, BB Be12, *RPBe12*.
Himachal Pradesh . .	Ap8, PoB8, Th 10, LM 11, *Fr F12*, *RP Be12*, BB Be 12
Jammu & Kashmir . .	AP8, LM 11, *Fr F 12*, *RP Be12*, BB Be 12.
Karnataka . . .	Ap8, *Th9*, Th10, LM11, *Fr F 12*, *RP Be 12*, BB Be 12.
Kerala	Ap8, *Th9*, LM 11, *St Bu 12*, S cal 4, *Fr F 12*, *RPBe12*, BB Be 12.
Madhya Pradesh . .	Fr B7, Ap8, *Th 9*, Th 10, LM 11, *Fr F 12*, RP Be 12, BB Be 12.
Maharashtra . . .	Ap8, 12, *Th 9*, Th 10, LM11, *FrF 12*, RP Be 12,
Manipur . . .	BB Be 12.
Orissa	*Ja 7*, Ap8, 12, *Th9*, LM 11, *Fr F12*, *RP Be 12*, BB Be 12
Punjab	BB Be 12, *Ja 7*, Fr B7, Ap8, Po B8, Th9, 10, LM 11, *St Bu 12*, *RP Be 12*.
Rajasthan	Ap8, *Th9*, LM11, *Fr F 12*, *RP Be 12*, Th 10, BB Be 12.
Tamil Nadu . . .	Fr B7, Ap8, *Th 9*, Th 10, LM 11, *Fr F 12 RP Be 12*, BB Be 12.
Tripura	Ap8, LM 11, *Fr F 12*, *RP Be 12*, BB Be 12.
Uttar Pradesh . . .	*RK E7*, Ap8, 12, Po. B8, LM11, *St Bu 12*, *Fr F 12*, *RP Be 12*, BB Be 12.
West Bengal . . .	Ap8, LM 11, *St Bu 12*, *Fr F 12*, *RP Be 12*, BB Be 12.

NOTE : Insect pests reported serious are italicised.

7 only for tomato
8. only for beans
9. only for chillies
10. only onion & garlic
11. only for peas
12. only for cucurbits
13. only for colocasia
14. only for tapioca.

APPENDIX 49.23 (Contd.)

(Paragraph 49.3.12)

II Serious and Moderate Diseases of Vegetables Crops

State	Information from States and from literature
Andhra Pradesh	DR2, *V2,6,7*, *EB17*, B1B1O, *PM1,2*, *DM1,2*.
Assam	*EB1, 2,7*, *LB1, 2*, DR2, *BaW2*, *V2,6,7*, Ba R5, *PM 1,2 DM 1, 2*.
Bihar	*EB1,2, 7*, *LB1,2*, Ch S2, oW2, DR2, *BaW2*, *V2, 6,7*, *PM 1, 2*, *DM1, 2*.
Gujarat	DR2, *V2,6,7*, *E B1,7*, *PM1,2*. *DM1,2*.
Harayana	DR2, 2 *V2,6,7*, *EB17*, *PM1,2*, *DM1,2*.
Himachal Pradesh	*E B 1, 7*, *EB1,2*, oW2, DR2, *V2,6,7*, *PM 1,2*, *DM1, 2* **LB1 2.**
Jammu & Kashmir	DR2, *V2,6,7*, *EB1,7*, *PM1,2*, *DM1,2*,
Karnataka	*EB1,2,7*, *LB1,2*, DR2, *BaW2*, *V2,6,7*, Ci, R5, B1, B10 S10, *PM1,2*, *DM1,2*.
Kerala	DR2, *V2,6,7*, *EB1,7*, *PM1,2*, *DM1,2*.
Madhya Pradesh	DR2, *V2,6,7*, *EB1, 7*, *PM1,2*, *DM1,2*.
Maharashtra	DR2, *BaW2*, *V2, 6,7*, BaR5, *EB1,7*, *PM1,2*, *DM1,2*.
Manipur	
Orissa	BaS2, DR2, *V2,6,7*, *E B1, 7*, *PM1,2*, *DM 1,2*.
Punjab	*E B1, 2,7*, *LB1,2*, BaS2, DR2, *BaW2*, *V2, 6,7*, *PM1,2*, *DM1, 2*.
Rajasthan	DR 2, *V2,6,7*. *EB1,7*, PM1,2, *DM1,2*.
Tamil Nadu	*E B1 2,7*, *LB 1,2*, DR2, *BaW2*, *V2,6,7*, Cl R5, B1B10, *PM 1,2*, *DM 1,2*.
Tripura	*E B1,2,7*, *LB1,2*, DR2, *V2,6,7*, *PM1,2*, *DM1,2*.
Uttar Pradesh	*EB 1,2,7*, *LB1,2*, oW2, DR2, *BaW2*, *V2, 6,7*, *PM1,2*, *DM 1,2*.
West Bengal	*EB1, 2,7*, *LB1,2*, DR2, *BaW2*, *V2,6,7*, *Wa2*, Ba R5, *PM 1,2*, *DM 1,2*.

NOTE : Diseases reported serious are italicised. Diseases reported serious by states are shown in thick type.

For the details of crops, please refer to Appendices 46.23 a,b,c.

APPENDIX 49.24

(Paragraph 49.3.12)

Abbreviations Used for Insect Pests and Diseases

Insects Pests	Diseases
A	
AW=army work	An=anthracnose
Ap=aphids	Al B=alternaria blight
	Al LS=alternaria leaf spot
B	
B=bug	BA=black arm
BB=blue beetles	BBl=blister blight
BaB=black bug	Br Bl=brown blight
BBBe=banded blister beetles	Bla=blast
BeB=beetles bug	BLB=bacterial leaf blight
BiHC=bihar hairy caterpillar	BR=black rust
BHaC=black headed caterpillar	BrR=brown rust
BHC=black hairy caterpillar	BuR=bud rot
BEC=bark eating caterpillar	BrRo=brown rot
BuF=butter fly	BaR=black rot
BW=bag worm	BiR=bitter rot
	BT=black tip
	BaS=black scurf
	Bu=bunt
	BaW=bacterial wilt
C	
CB=cashew borers	Ca=canker
CoB=cockchafer beetle	CR=collar rot
Ch=chafers	ClR=club rot
Cr=cricket	ChS=charcoal stump rot
CaW=case worm	Cs=covered smut
CW=cut worm	
D	
DBM=diamond back moth	DB=die back
DaCB=dusky cotton bug	DM=downy mildew
DWGH=deccan wingless grasshopper	DR=dry rot
	DO=damping off

APPENDIX 49.24 (Contd.)

Insects Pests	Diseases
	E
E=eelworms	Er=ergot
EpBe=epilachna beetle	EBl=early blight
EhB=earhead bug	
EC=ear cockle	
ECC=ear cutting caterpillar	
EhWC=earhead webbing caterpillar	
	F
FrB=fruit borer	FS=flag smut
FlB=flea beetles	FR=foot rot
FCr=field cricket	FrR=fruit rot
FrF=fruit flies	
FHB=flower head bug	
FluS=fluted scale	
FSM=fruit sucking moth	
FSB=fruit & shoot borer	
	G
GB=gundhi bug	GED=green ear disease
GrB=green bug	Gu=gummosis
GBo=ginger borer	GrBl=grey blight
GC=gram caterpillar	GD=gall disease
GF=gall fly	GrM=grey mildew
GLH=green leaf hoppers	GS=grain smut
Gib=girdle beetle	
GNe=golden nematode	
GM=gall midge	
GPAp=green peach aphids	
GrW=grey weevil	
GH=grasshopper	
GW=gram weevil	
	H
H=hispa	He=helminthosporium
Ho=hoppers	
HC=hairy caterpillar	
HM=hawk moth	
	J
Ja=jassids	

APPENDIX 49.24 (Contd.)

Insects Pests	Diseases
	L
L=lopper	Leb=leaf blotch
LC=lucerne caterpiller	LBl=late blight
LeC=leaf caterpillar	LeF=leaf fall and fruit rot
LeEC=leaf eating caterpillar	LeR=leaf rot
LGF=leaf gall fly	LeS=leaf spot
LM=leaf miner	LS=loose smut
L&PC=leaf and pod caterpillar	
LR=leaf roller	
LWB=lace wing bug	
	M
M=midge	Mo=molya
Mi=mites	Mal=malformation
MB=mealy bug	MR=mouldy rot
MoCr=mole cricket	
MoS=mosquitoes	
	N
Ne=nematode	NuF=nut fall and bud rot
	O
OBB=orange beetle borers	OW=ozonium wilt
	P
Ps=psylla	Po=pollu
PY=pyrilla	PhB=phytophthora blight
PaB=painted bug	PoBl=pod blight
PB=pink borer	PM=powdery mildew
POB=pod borer	PD=pink disease
PH=plant hoppers	
PF=pod fly	
PBW=pink bollworm	
	R
RA=red ant	R=rust
ReB=red bug	ReR=red rot
ReBo=red borer	ReRl=red rust
RB=root borer	RR=root rot
RAP=root aphids	RhiR=rhizome rot
RhB=rhinocerus beetle	ReRR=red root rot

APPENDIX 49.24 (Contd.)

Insects Pests	Diseases
RCB=red cotton bug	
RGE=root gall eelworm	
RHC=red hairy caterpillar	
RSlu=red slug	
RPW=red palm weevil	
RS=red spider	
RMi=red mites	
RSMi=red spider mites	
RPBe=red pumpkin beetle	
ReS=red scale	
RW=root weevil	
S	
Sk=skipper	Si=sigatoka
SB=stem borer	Sb=scab
SBW=spotted bollworm	S=smut
Sl=semilooper	StB=stem bleeding
Sca=scale	SBa=stem black
SC=swarming caterpillar	SBr=stem brown
S&CB=shoot and capsule borer	SB&F=sooty blotch and fly speck
SpB=spindle bug	StD=stripe disease
SG=stem girdler	SuD=sugary disease
SaF=saw fly	SR=sett rot
SF=stem fly	
St Bu=stink bug	
Sluc=slug caterpillar	
SHB=shoot hole borer	
SJS=san jose scale	
SW=stem weevil	
T	
Te=termites	Ti=tirak
Th=thrips	Tik=tikka
TBe=tortoise beetle	TV=tungro virus
TC=tobacco caterpillar	
TeC=tent caterpillar	
TSB=top shoot borer	
V	
	V=Virus

APPENDIX 49.24 (Concld.)

Insect Pests	Diseases
	W
W=weevils	Wa=wart
WB=white borer	Wi=wilt
WG=white grub	WR=white rust
WF=white fly	WT--whiter tip & fruit fall
WAP=wooly aphids	
WLH=white leaf hopper	
	Y
	YR=Yellow rust
	Z
	Zn=Zinc deficiency

APPENDIX 49·25

(Paragraph 49·4·1)

Maximum Protection Trial for Chemical Control of Insects

Summary of grain yields obtained in trials in kharif 1969, using five varieties of rice possessing varying reaction to known pests.[1]

Location	Grain yield (kg/ha)					Local variety used
	IR 8	T(N) I	W 1263	CR 44 93	Local	
1	2	3	4	5	6	7
Warangal						
treated	4188	4690	4084	2727	3420	HR 35
untreated	505	656	2245	1102	720	
difference	3683	4034	1839	1625	2700	
% increase	729	615	82	147	375	
Tenali						
treated	4332	3411	2834	3706	3069	MTU 20
untreated	1227	672	2404	2412	2204	
difference	3105	2739	430	1294	865	
% increase	253	407	18	57	39	
Maruteru						
treated	3130	1602	1679	4065	2215	MTU 20
untreated	1371	145	1241	2655	969	
difference	1759	1457	438	1410	1248	
% increase	129	1005	35	53	129	
Aduthurai						
treated	3995	2959	3077	3834	3039	Co 32
untreated	2548	2479	2908	2562	2645	
difference	1447	480	169	1272	294	
% increase	57	19	6	50	15	
Cuttack						
treated	4428	3956	2814	3272	3527	CR 1014
untreated	3251	3031	3210	3439	3620	
difference	1177	925	—396	—167	—93	
% increase	36	30	—1	—5	—3	
Patna						
treated	2792	517	..	..	2858	BR 34
untreated	1750	400	..	..	2604	
difference	1024	117	..	..	254	
% increase	29	29	..	..	10	

APPENDIX 49.25 (Contd.)

1	2	3	4	5	6	7
Jorhat						
treated . . .	3667	4268	3162	3482	3327	Ch 63
untreated . .	2673	2472	2282	2404	2318	
difference .	994	1792	800	1078	1009	
% increase . .	37	72	39	23	43	
Hyderabad						
treated . . .	2460	3923	1092	2905	..	
untreated . .	1714	2035	994	2544	..	
difference . .	746	1880	98	361	..	
% increase . .	43	93	10	14	..	
Ranchi						
treated . .	1808	3125	..	..	2075	BR 34
untreated . .	1116	1050	..	..	1550	
difference . .	692	2075	..	..	525	
% increase . .	62	198	..	..	34	
Coimbatore						
treated . . .	3593	3246	2717	..	..	
untreated . .	3280	2530	2592	..	..	
difference . .	313	716	125	..	..	
% increase . .	9	28	5	..	..	
Raipur						
treated . . .	6360	5517	3252	..	..	
untreated . .	6077	5051	3775	..	..	
difference . .	313	466	—523	..	..	
% increase . .	9	9	—14	..	..	
Pantnagar						
treated . . .	7755	7309	4522	7129	5620	Ch 4
untreated . .	7479	6301	4892	6136	4876	
difference . .	256	1006	—370	993	744	
%increase . .	3	16	—8	16	15	
Karjat						
treated . . .	2622	2128	2300	..	..	
untreated . .	2589	1739	2033	..	..	
difference . .	33	389	267	..	..	
% increase . .	1	22	13	..	..	

APPENDIX 49.25 (Contd.)

1	2	3	4	5	6	7
Kapurthala						
treated	3553	4582	3057	4401	2906	Jhona 20
untreated	3657	4378	3151	4219	2521	
difference	—124	204	—94	182	385	
% increase	—3	5	—3	4	13	
Mean						
treated	3903	3660	2883	3947	3208	
untreated	2902	2353	2644	3053	2403	
difference	1093	1307	239	894	803	
% increase	108	194	14	45	76	

1. Progress Report of the All India Coordinated Rice Improvement Project. Vol. 3. Pathology and Entomology. Kharif. 1969. Indian Council of Agricultural Research, New Delhi, India and Co-operating Agencies. pp 11.3—11.4.

APPENDIX 49·25 (Contd.)

(Paragraph 49·4·1)

I. Incidence of Neck Infection and Yield of Rice in Blast Control Trial with Foliar Sprays of Fungicides, Kharif, 1969.[1]

Location	Control	Kasumin (0·5 q)	Kasumin (1 q)	Aureo-funggin	Kitazin	Duter	Hinosan	Fytolan	CD (0·05)
				percent neck infection					
CRRI	29·21	9·36*	9·17*	26·37	11·16*	17·71*	3·82*	11·99*	6·50
Coimbatore	38·88	26·57*	24·74*	32·32*	28·02*	31·22*	27·18*	29·34*	3·70
Aduthurai	22·62	16·02*	—	16·73*	13·50*	15·81*	14·60*	15·93*	3·16
Raipur	35·19	33·96	30·10	39·44	27·49	15·13	27·71	20·19	9·84
Lonavla	28·65	20·16*	17·42*	22·70*	23·95*	21·53	20·15*	21·94*	2·42
Nellore	32·10	15·03	14·07	19·80	18·40	17·70	13·60	18·50	**
				yield in kg/ha					
CRRI	808	1401	1663	933	1360	1525	1694	1239	490
Coimbatore	1457	1618	1670	1349	1774	1558	1679	1527	244
Aduthurai	2320	2346	——	2325	2229	1466	2286	2417	—
Raipur	3471	3200	3600	3259	3401	3896	3580	3591	419
Lonavla	788	1327	1455	1173	1160	1205	1397	1205	141
Nellore	2336	2571	2882	2334	2664	2631	2708	2084	316

*Significant treatment

—— Not tried

** Not known

[1] Progress Report of the All-India Coordinated Rice Improvement Project. Vol 3. Pathology and Entomology. Kharif, 1969. Indian Council of Agricultural Research, New Delhi, India and Cooperating Agencies. p. 7.3.

APPENDIX 49·25 (Concld.)

(Paragraph 49·4·1)

II. Effect of Fungicides and Antibiotics on Control of Blast Disease of Rice (Variety ADT 27)[1]

Fungicide or antibiotic	Dosage	% of neck infection	Av. yield per ha. in kg.	Yield in percentage over contr.
brestanol	0·440 gm	14·99 (21·89)*	2228·57	111·40
duter WP	2·5 gm	9·96 (18·82)	2222·22	110·80
hinosan 50% EC	1·5 ml.	4·07 (11·49)	2228·57	111·40
blitox 50	7·54 gm	17·30 (23·81)	1574·60	43·30
kasumin 2% WP	1·0 gm	11·78 (20·03)	2539·68	141·00
kasumin 20% WP.	1·5 gm	9·12 (17·14)	1428·57	35·50
control		37·66 (37·83)	1053·97	00
S.E.		(4·21)	330·16	
C.D. (at 5% level)		(9·17)	717·46	

*Figures in parentheses indicate angular value.

[1]Mohanty, N.N. and S.C. Dash, 1971.

Efficacy of different fungicides and an antibiotic on control of blast of rice. *Ind. Phytopath.*, *24*(3) : 509—513.

APPENDIX 49·26

(Paragraph 49·4·1)

I. Effect of Fungicides in Controlling Rusts of Wheat (Variety S 227)[1]

Treatment	Incidence of rust (%)		Yield/ha. (in kgs.)
	Black rust	Brown rust	
RH 539	28	20	2,042
plantvax	28	22	2,042
zineb	36	26	1,950
dithane M-45	36	28	1,884
wettable sulphur	38	30	1,884
control	57	46	1,600
significance by 'F' test	HS	HS	HS
SEM	2·22	2·07	42·00
C.D.	4·73	4·41	89·67

1 Pandit, S.V. Progress of work done in Wheat Pathology during 1969-70 in Andhra Pradesh. In papers presented at the 1970 All-India Wheat Research Workers' Workshop held at Delhi (August 25—26, 1970) Vol. 5, pp 301—305.

APPENDIX 49·26 (Contd.)

(Paragraph 49·4·1)

II. Effect of Fungicides on Control of Rusts (1965-66) of Wheat (Variety Agra local)[1].

Treatments	Dose lb/ha*	Average intensity of disease (per cent)		Yield/ha (Qtls)
		Leaf rust	Stem rust	
maneb	7·40	6·60 **(14·67)	1·59 (7·13)	38·37
zineb	7·40	7·29 (15·62)	2·64 (9·20)	36·05
thiovit.	7·40	21·65 (27·19)	5·81 (13·87)	31·68
ziram	2·5	27·34 (31·49)	10·99 (19·09)	28·67
aretan	4·90	28·94 (32·30)	16·64 (23·86)	27·88
control	..	51·19 (45·69)	23·23 (28·74)	23·87
LSD at 5 per cent . .		(6·67)	(4·73)	(2·63)

*Dose converted to lb/ha from lb/acre.

*Figures in parentheses indicate angular value

Tandon, I.N., B.K. Singh and R.S. Mathur, 1958. Control of wheat rusts with fungicides. *Indian hytopath.* 21 (4) : 389—396.

APPENDIX 49·26 (Contd.)

(Paragraph 49·4·1)

III. Effect of Fungicides on the Control of Wheat Rust, 1966-67[1]

Treatments	Dose lb/ha*	Average intensity of disease (per cent)			Yield/ha. (quintals)
		Leaf rust	Stem rust	Stripe rust	
bisdithane	7·40	6·19 **(14·34)	0·56 (4·20)	5·10 (13·07)	45·50
maneb	7·40	6·40 (14·65)	0·62 (4·45)	5·27 (13·29)	43·96
dithane S-31 . . .	7·40	8·54 (16·97)	1·21 (6·29)	8·32 (16·78)	42·25
zineb	7·40	8·17 (16·52)	1·55 (7·01)	8·86 (17·30)	42·04
thiovit	12·35	15·87 (23·46)	3·27 (10·20)	13·90 (21·87)	38·00
N-3412	7·40	19·54 (26·24)	3·06 (9·86)	9·17 (17·63)	35·71
miltox	10·00	21·41 (27·52)	4·05 (11·38)	17·21 (24·49)	35·07
ziram	5.00	24.41 (29·59)	4.49 (11·99)	21.30 (27·49)	34.39
aureofunjin	7·40 gms	37·30 (37·92)	11·01 (19·36)	32·96 (35·01)	25·54
control	..	37·99 (38·03)	11·09 (19·41)	33·37 (35·29)	27·07
LSD at 5 per cent . .		(2·15)	(2·24)	(1·83)	2·79

*Dose converted to lb/ha from lb/acre

** Figures in parentheses indicate angular value.

[1] Tandon .I.N., B.K. Singh and R.S. Mathur, 1968. Control of Wheat rusts with fungicides, *Indian-Phytopath.*, *21* (4) : 389—396.

APPENDIX 49·26 (Contd.)

(Paragraph 49.4.1)

IV. Effect of Fungicides in Controlling *Alternaria* Leaf Blight of Wheat (Variety K 25)[1]

Treatment	Incidence of Alternaria leaf blight (%)	Yield/ha. (in kg.)
plantvax	27·50	1,400
zineb	32·00	1,384
dithane M-45	32·50	1,333
RH 539	30·00	1,317
wettable sulphur	37·00	1,266
control	46·50	1,233
significance by 'F' test	No	Yes
SEm	..	47·97
CD	..	102·23

[1]. Pandit, S.V. Progress of work done in Wheat Pathology during 1969-70 in Andhra Pradesh. In papers presented at the 1970 All-India Wheat Researc Workers Workshop held at Delhi (August 25—28, 1970) Vol. 5.
Wheat Research Coordination Centre. All India Wheat Improvement Project, New Delhi 301—305.

APPENDIX 49.26 (Concld.)

(Paragraph 49.4.1)

V. Effect of Fungicides on Control of Leaf Blight of Wheat (Variety Kenphad 25)[1]

Treatments	Dose	Average intensity of disease per cent.			Yield in Q/ha			% increase in yield over control at		
		Kanpur	Arual		Kanpur	Arual		Kanpur	Arual	
		1967-68	68-69	68-69	1967-68	68-69	68-69	1967-68	68-69	68-69
dithane Z-78 . . .	0·25%	32·1 (34·5)	45·5 (42·4)	27·0 (31·30)	11·04	20·14	29·81	160·99	16·55	42·29
dithane M-45 . .	,,	48·30 (44·00)	35·10 (36·3)	21·90 (27·90)	10·78	26·69	28·17	154·84	56·46	34·46
bisdithane . . .	,,	40·65 (39·6)	..	..	7·16	..	..	69·27	..	..
cuman	,,	50·7 (45·4)	59·55 (50·5)	33·45 (35·33)	8·02	17·31	25·16	89·60	0·17	20·09
karathane . . .	,,	55·8 (48·3)	50·9 (45·5)	48·75 (44·27)	5·35	18·90	24·64	26·48	9·37	17·47
cosan	,,	73·65 (59·1)	57·65 (49·4)	51·30 (45·73)	3·54	18·17	21·75	16·31	5·15	3·82
Control . . .	,,	77·10 (61·4)	71·50 (57·7)	69·15 (56·25)	4·23	17·28	20·95	..	..	..
CD at 5% . . .		(3·65)	(5·05)	(8·56)	4·08	4·98	6·24	..	..	..

*Figures in parentheses indicate angular value.

1 Singh, D.V. and V.K. Singh, 1971. Control of leaf blight of wheat with fungicides. *Indian Phytopath.*, 24 (4) : . 694—697.

APPENDIX 49.27

(Paragraph 49·6·2)

Variation in the Use of Chemicals and Their Dosages for Rice Crop

(Kg/ml per hectare)

Name of chemicals	*Andhra Pradesh	*Karnataka	*Haryana	*Orissa	Maharashtra	Uttar Pradesh	Tripura
BHC 5% dust	..	..	..	..	..	38·00	4·00
10% dust	25·00	..	25·00	15·00	10·00	26·00	21·25
50% WP	5·00	..	..	..	..	10·25	..
DDT 50% WP	5·00	..	..	2·25	1·50	..	..
25% EC	..	..	..	..	..	..	5500
Phorate 10% G	14·00	24·00	..	11·25	10·00	..	..
DDVP 100% EC	200	..	..	..	..	..	..
parathion 46·7% EC	..	..	..	..	..	..	..
50% EC	740	1170	..	..	..	340	375
2% dust	..	..	..	..	..	30·00	..
NM	..	..	..	..	..	..	..
methylparathion 50% EC	..	..	365	..	..	..	..
endrin 20% EC	930	2930	2160	..	1000	1195	1050
2% G	..	..	..	..	..	..	..
NM	..	..	..	..	..	11·25	..
lindane 5% G	..	..	25·00	..	..	..	..
6% G	..	..	..	..	25·00	..	..
10% G	20·00	..	..	..	..	..	..
20% EC	..	..	..	..	..	..	2250

NM	..	..	..	..	..	..	..
fenitrothion 50% EC	740	..	..	..	500	690	..
100% EC	..	..	..	..	..	..	..
5% dust	..	..	..	..	..	22·50	..
diazinon 5% G	30·00	..	..	50·00	..	..	..
20% EC	..	..	..	..	..	..	1900
NM	..	..	..	0·20	..	..	..
carbaryl 10% dust	25·00	..	..	..	10·00	..	..
50% WP	..	..	..	2·50	2·00	..	..
aldrin 5% dust	62·00	..	..	..	..	..	..
30% EC	..	..	..	..	..	..	..
40% WP	5·00	..	..	..	..	..	..
heptachlor 5% dust	62·00	..	..	..	..	..	..
chlordane 5% dust	..	..	..	..	..	..	..
endosulfan 35% EC	..	..	..	..	..	875	1010
NM	..	..	..	..	..	..	..
toxaphene 10% dust	25·00	..	..	..	..	..	..
metasystox 25% EC	..	..	..	..	..	..	650
dimethoate 30% EC	..	1950	..	..	..	..	..
phosphamidon 100	..	1250	..	..	200	240	..
malathion 5% dust	..	20·00	..	..	..	..	..
50% EC	..	..	..	1000	1000	..	1025

*Figures converted from per acre to per hectare.
N.M. Formulation not mentioned.

APPENDIX 49·27 (Concld.)

(Kg/ml per hectare)

Name of chemicals	Manipur	Assam	West Bengal	*Rajasthan	J & K	*Himachal Pradesh	*Naga-land	Bihar
BHC 5% dust	..	..	..	..	..	..	14·00	37·00
10% dust	25·00*	15·00	27·00	..	28·00	25·00	..	25·00
50% WP	0·04	2·50	5·00	0·85	4·00	..	..	..
D DT 50% WP	..	..	5·00	1·25	2·50	..	..	..
25% EC	..	..	..	..	..	..	..	..
phorate 10% G	..	..	..	..	12·50	..	..	15·00
DDVP 100% EC	..	..	..	..	..	..	..	..
parathion 46·7% EC	..	..	..	395	..	..	..	..
50% EC	..	..	..	..	..	445	..	..
2% dust	..	..	..	..	..	..	..	..
NM	70	..	495	..	..	..	..	445
methyl parathion 50% EC	..	..	..	..	..	..	..	..
endrin 20% EC	..	1250	..	1165	..	..	..	..
2% G	..	..	..	..	..	12·25	..	..
NM	..	..	495	..	..	..	..	..
lindane 5% G	..	..	..	..	..	..	..	..
6% G	..	..	..	..	..	..	..	..
10% G	..	..	..	..	..	..	..	..
20% EC	..	..	..	..	..	..	..	..

NM	..	1·50	1235	..	..	..	..	..
fenitrothion 50% EC	..	..	..	..	..	..	..	..
100% EC	..	..	..	..	..	..	..	310
5% dust	..	..	..	..	..	..	..	..
diazinon 5% G	..	..	..	..	..	..	..	22·25
20% EC	..	1250	..	..	..	..	..	..
NM	70	..	..	..	..	..	..	..
carbaryl 10% dust	..	..	..	..	..	..	..	25·00
50% WP	..	..	5·00	..	..	..	..	..
aldrin 5% dust	..	..	..	..	..	..	..	37·00
30% EC	..	..	..	..	1250	..	..	..
40% WP	..	..	..	..	..	..	..	..
heptachlor 5% dust	..	..	..	..	..	..	..	37·00
chlordane 5% dust	..	..	..	..	..	..	..	37·00
endosulfan 35% EC	..	..	..	..	..	..	..	..
NM	..	..	..	..	..	..	..	123 5
toxaphene 10% dust	..	..	..	..	..	..	..	..
metasystox 25% EC	..	..	..	..	..	1110	..	620
dimethoate 30% EC	..	..	..	..	..	1110	..	..
phosphamidon 100	..	..	..	245	150	335	..	270
malathion 5% dust	..	..	..	..	..	..	..	..
50% EC	..	..	..	..	..	..	..	..

*Figures converted from per acre to per hectare. N.M. Formulation not mentioned.

NOTE : Figures represent average dose of respective chemicals with respect to one application for different insect pests.

APPENDIX 49·28

(Paragraph 49·6·4)

Benefit Cost Ratio with Chemical Plant Protection Measures in Different Corps[1]

Pest/disease/weeds	Insecticide/fungicide/herbicide	Cost of chemical treatment/acre (Rs.)*	Benefit per acre (Rs.)*	Benefit cost ratio	Author	Remarks
1	2	3	4	5	6	7
		paddy				
blast	copper oxychloride	10	30	3	Padmanabham *et al.* 1956	4S
blast/brown spot/gall fly/stem borer/rats .	BHC, copper oxychloride and parathion	42	78	1·8	Seth *et al.* 1969	3T
weeds	2, 4-D	6	28	4·6	Anon 1964	1S
stem borer	endrin	30	200	6·6	Sengupta, 1963	2S
weeds	stem F-34	55	225	4	Mukhopadhyay, 1966	
		jowar				
stem borer	endrin granule	57	396	7·2	Ahmed & Young, 1969	4A
		sugarcane				
plasey borer	endrin, BHC+DDT mixture	13	160	12·6	Banerjee, 1958	1S from air and ground

early shoot borer	endrin	20	279	14	Ramachandrachari and Mohan Rao, 1958	3S
early shoot borer	DDT	34	220	6	,,	3S
early shoot borer	lindane granule	37	492	13	Vardharajan, *et al.* 1970	
top borer	endrin	32	340	10·6	Singh *et al.* 1956	1S against 3rd brood
top borer	,,	73	475	6·5	,,	2S against 3rd & 4th broods.
top borer	,,	97	327	3·4	,,	3S against 2nd, 3rd &4th broods
		potato				
early and late blight	dithane Z-78	58	275	4·7	Anon, 1970	4S in the plains
early and late blight	,,	175	241	1·4	,,	6S in the plains
		brinjal				
fruit borer	carbaryl	70	240	3·4	Jotwani & Sarup, 1963	3S
fruit borer	DDT+BHC mixture	84	297	2·8	,,	3S
		groundnut				
soil pests	pherate	87	120	1·4	Kulshreshtha *et al.* 1964	1T

APPENDIX 49.28—(Concld.)

1	2	3	4	5	6	7
white grub	BHC	23	124	5	Kulshreshtha *et. al.* 1964	1T
foot rot	captan	5	220	44	,,	1T
tikka leaf spot	bordeaux mixture	39	78	2	Lewis & Natarajan, 1971	3S
tikka leaf spot	brestan	55	94	1·7	,,	3S
		cotton				
jassids	DDT+BHC mixture	6	125	19	Varma, 1957	1S
		cotton (Vijalpur variety)				
bollworms	carbaryl	50	111	2	Patel & Patel, 1965	5S
		cotton (Devraj variety)				
bollworms	,,	50	202	4	,,	5S
all pests	DDT+BHC, endrin	171 (1965)	2006	11·7	Atwal & Singh, 1969	6S
all pests		(1966)	2013	13·5		
all pests	thiometon	253	2508	9·9	,,	6S
all pests	dimethoate, DDT	199	2014	10	,,	6S
all pests	DDT+BHC, malathion	147	1735	11·8		4S+2S
all pests	carbaryl+sulphur	134	1101		Kanniyan *et al.* 1969	6D

jassids and bollworms	phosphamidon and DDT+ BHC mixture	95	285	3	Butani & Sahni, 1971	4S
		mustard				
aphids	menazon or phosphamidon or malathion dimethoate or methyl demeton or parathion or phosphamidon or menazon	57 (average)	632	11	Chahal & Sukhija, 1969	
			jute			
all pests	endrin	42	167	4	Tripathi & Ram, 1970	5S
		coconut				
leaf rot, bud rot, stem bleeding, mahli & leaf blight.		27	50	1·9	Thomas, 1963	3S

1. Varma, B. K., 1372. Chemical Control in plant protection, *Pesticides*. 6(1) : 15-18.
*For calculating per hactare multiply by 2.4.
S=Spraying, T= treatments, A=applications; D=dustings.

APPENDIX 49·29

(Paragraph 49·6·5)

Benefit-cost Ratio of Chemicals Used for Plant Protection

Name of State	Paddy	Wheat	Maize	Bajra	Pulses	Cotton	Oil seeds	Sugar cane	Jute	Vege-tables	Po-tato	Brin-jal	Lady's finger	To-mato	Man-go
Assam	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bihar	..	..	..	..	..	7·6	..	..	..	..	..	..	..	..	..
Haryana	10	5	5	5	..	10	5—10	5	..	5	..	..	..	..	..
Himachal Pradesh	4	3·3	..	..	..	..	..	..	..	..	10	..	..	10	..
Jammu & Kashmir	..	..	..	..	..	..	3·1—5·9	..	..	..	..	..	..	..	..
Manipur	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Orissa	4·4 (rabi) 4·6 (kharif)	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tripura	6·4 (aus)	..	..	..	..	..	2·4—2·5	..	1·9—3·8	..	4·7	13—55	17·5	..	..
West Bengal	4·4 (boro) 12·7 (aman) 2·76	4	..	..	2	3·1	2—2·6	16	..	8	9·6	..	..	..	7

APPENDIX 49·30

(Paragraph 49.7.11)

Categorywise and Cropwise Break-up of 100 Million Hectares—Level to be Reached by 1978-79[1]

(Area million hectares)

Crop/Area				Area earmarked for plant protection treatment						
Total cropped area			Area under intensive cultivation	Seed treatment	Rat control	Weed control	Intensive treatment on surface and soil pest			
Name of the crop	69—70	78—79	HYP etc./Irrigated				Net area	..	Repli-cation No.	Gross area to be treated—sprayed/dusted
1	2	3	4	5	6	7	8	9		10
wheat	16·60	21·00	12·50	2·00	6·00	1·00	2	..	1	2·00
paddy	37·70	40·00	18·00	6·00	2·00	2·00	18	..	2	36·00
maize	5·90	6·50	1·50	0·50	..	0·25	1	..	1	1·00
jowar	18·60	19·00	3·50	6·00	..	..	3	..	1	3·00
bajra	12·50	13·50	4·50	0·50	1·50	0·25	2	..	1	2·00
. . .	123·50	139·50	40·00	15·00	9·50	3·50	26			44·00
Other crops			Irrigated area outside HYP							
pulses	22·00	..	3·00	0·50	..	0·10	0·50	..	1	0·50
cotton	7·83	..	3·00	2·00	..	0·25	3 2	.. ..	2 1	6·00 2·00

APPENDIX 49·30 (Concld.)

1	2	3	4	5	6	7	8	9	10
jute	0·70	..	0·25	0·05	..	0·10	0·50	.. 2	1·00
potato	0·50	..	..	0·05	..	..	0·30	.. 2	0·60
oilseeds	14·64	..	2·00	1·00	1·50	0·10	2·60	.. 1	2·60
sugarcane	2·75	..	2·50	1·40	0·50	0·25	2·00	.. 2	4·00
tobacco	0·42	..	0·10	—	..	0·10	0·40	.. 2	0·80
other crops fruits & plantation crops & vegetables . .	..	..	4·35	1·00	0·50	0·10	1·00	.. 1	1·00
			15·00	6·00	2·50	1·00			18·50
GRAND TOTAL			55·00	21·00	12·00	4·50			62·50

=100 million hectares

1. Fifth Five Year Plan (1974-79)—Report of the Task Force IV on Pesticides—Ministry of Petroleum & Chemicals, Government of India.

APPENDIX 49.31

(Paragraph 49.7.12)

Summary of Information obtained on the Requirement of Chemicals by States

States	Summary of information
Andhra Pradesh	yearwise requirement of chemicals in technical grade from 1972-73 to 1978-79.
Assam	no information given.
Bihar	total requirement of insecticides under major kharif and rabi crops in terms of chlorinated hydrocarbons, OP compounds, carbamates and other insecticides; total acaricides, rodenticides, nematicides, herbicides and organomercurials for 1974-79, 1979-84 and 1984-89.
Gujarat	no information given.
Haryana	yearwise requirement of chemicals in lit/kg, some as formulated products, others not mentioned, from 1972-73 to 1978-79.
Himachal Pradesh	yearwise requirement of chemicals in lit/kg, some as formulated products, others not mentioned, from 1972-73 to 1974-75.
Jammu & Kashmir	yearwise requirement of chemicals, some as forumulated products, others not mentioned, from 1972-73 to 1978-79.
Maharashtra	yearwise requirement of chemials as formulated prol ducts from 1972-73 to 1976-77.
Manipur	yearwise requirement of chemicals, some as formulated products, others not mentioned from 1972-73 to 1978-79.
Nagaland	yearwise budget provision for purchase of chemicals from 1974-75 to 1978-79 (list of chemicals not prepared).
Karnataka	yearwise requirement of chemicals, in technical grade, from 1974-75 to 1978-79.
Orissa	yearwise requirement of chemicals, only names mentioned, from 1972-73 to 1978-79.
Raasthan	requirement of chemicals in MT for 1974-75. Whether in terms of technical material or formulation, not mentioned.
Tripura	no information given.
Uttar Pradesh	yearwise requirement as insecticides, fungicides, rodenticides, herbicides and others from 1972-73 to 1978-79.
West Bengal	yearwise requirement of chemicals, only names mentioned, from 1973-74 to 1978-79.

APPENDIX 49.32

(Paragraph 49.7.13)

Summary of information obtained on the Basis on which Annual Targets for Chemicals and Evaluation of Achievements are made by States

States	Summary of the basis and evaluation of achievements
1	2
Andhra Pradesh . .	depending on the plant protection targets fixed for the State, the pesticides requirements are worked out for various crops.
Assam	cropwise area under improved practices of cultivation and recommended measures are considered.
Bihar	achievement of the previous years state plan regarding cropping patterns and area sown; strength of staff and plan of endemic area.
Gujarat	trends in the growth and spread of area under high yielding varieties of which a certain portion may be considered to be covered by plant protection measures on a hypothetical basis; cultivators' likings for certain pesticides and their trends in switch-over from one to another; normal epidemic cycles of certain unsual pests and diseases and climatic functions; market trends in short supply of certain imported chemicals and subsequent switch-over to alternate ones and market trend in agricultural production prices which sometimes reflect in the economics of the pesticides usage.
Himachal Pradesh . .	previous achievements of crop target. Evaluation made on the basis of percentage of targets achieved.
Jammu & Kashmir . .	recurring problem of the specific areas (cutworm endemic maize stemborer); achievements of previous years; new pest and disease problems.
Maharashtra . . .	finalising the programme of proposed work to be taken which is 10-15% higher than the previous year; on the basis of this, requirement of plant protection chemicals worked out as per recommended schedule and also consumption during previous years. Net requirement derived -minus stock in hand from total requirement; provision for carry over to next year and for epidemic.
Manipur	past experience and production target fixed under different agricultural production programmes particularly high yielding programme.

APPENDIX 49·32 (Concld.)

1	2
Nagaland	availability of funds and requirement of chemicals sufficient for two dusting/spraying in one crop life as in a year.
Karnataka	uptake of pesticides in previous years, programmes under high yielding variety and other normal programmes, normally, 20% over and above the previous year's uptake is taken for consideration evaluation is only in respect of sales through several agencies dealing in pesticides.
Orissa	overall target under high yielding varieties; on the basis of recommended package of practices for particular crops and supply and availability of materials through cooperatives and private agencies is ensured. Evaluation on the basis of consumption of pesticides.
Rajasthan	plant protection work done during the ast 2-3 years and the possiblities of the availability of chemicals.
Tripura	area under cultivated crops to be brought under plant protection practices in the year along with a provision for carry over stock for the next year evaluation through periodical records collected from utilisation centres.
Uttar Pradesh . . .	no targets for chemicals are laid out; depends on availability of different chemicals; planning done on the basis of area coverage by the agency of the plant protection service in the state.
West Bengal	acreage under different crops and their varieties and also last year's achievements.

APPENDIX 49·33

(Paragraph 49.7.14)

Estimated Requirement of Pesticides Cropwise by 1978-79

(in tonnes of technical materials)

Name of pesticides	Crops							
	paddy	wheat	maize	jowar	bajra	pulses	sugracane	cotton
1	2	3	4	5	6	7	8	9
Insecticides								
BHC	15,530	6,420	660	1,660	4,560	3,000	2,500	..
DDT	2,830	..	..	..	..	1,500	..	..
aldrin	..	2,060	20	..	..	..	..	..
heptachlor	..	2,020	..	..	..	..	1,120	..
chlordane	..	1,870	..	..	..	..	..	..
endosulfan	70	..	30	830	70	..	510	..
carbaryl	3,550	..	530	1,060	..	..	..	3,000
malathion	670	3,600	120	440	140	750	630	—
parathion	..	..	..	..	..	..	..	..
metasystox	10	..	..	..	..	..	..	..
fenitrothion	210	..	30	..	..	..	..	..
dimethoate	450	..	..	..	..	..	..	..
phosphamidon	320	30	70	..	..	320	..	260

APPENDIX 49·33 (Contd.)

Name of Pesticides	Crops				1978-79 estimated requirement	installed capacity	capacity covered by licence/letter of intent	capacity likely to be created in public sector	likely gap to be filled up
	jute	oilseeds	tobacco	fruits, plantation & others					
1	10	11	12	13	14	15	16	17	18
insecticides									
BHC	50	2,000	..	..	36,380	26,800	37,540	..	..
DDT	..	..	..	710	5,040	4,200	4,200	500	..
aldrin	..	..	..	..	2,080	..	..	..	2,080
heptachlor	..	..	..	..	3,140	..	..	..	3,140
chlordane	..	..	..	..	1,870	..	..	..	1,870
endosulfan	530	310	neg(2)	80	2,430	..	1,600	1,600	830
carbaryl	..	..	..	160	8,310	..	7,000	..	1,310
malathion	10	460	neg(3)	150	6,970	1,475	1,125	1,800	3,370
parathion	..	..	..	..	..				
metasystox	..	60	..	10	80	4,300	1,000	..	..
fenitrothion	..	..	..	120	360				
dimethoate	..	..	..	70	520	350	..	..	170
phosphamidon	..	..	..	60	1,060	636	..	..	424

APPENDIX 49.33 (Contd.)

1	2	3	4	5	6	7	8	9
insecticides (contd.)								
DDVP	280	..	40	..	100	..	..	..
monocrotophos	..	..	..	..	..	..	..	410
phorate	680	..	..	20	..	..	..	..
carbofuran	3,950	..	..	170	..	..	..	..
fungicides								
copper oxychloride	730	..	50	..	840	..	..	750
zineb	..	7,660	240	20	80	..	..	..
maneb	..	..	..	..	..	..	..	..
mancozeb	..	80	290	10	..	1,710	..	..
ziram	..	..	..	600	430	..	..	..
thiram	..	1,170	20	..	40	..	..	..
organo mercurials	6·2	14·1	0·2	0·3	0·4	3·1	0·4	1·6
sulphur (wettable & dust)	..	..	..	50	..	..	1,980	3,840
hinosan	670	..	..	..	..	..	..	..
duter	..	..	..	..	..	..	..	..
brestan	..	..	..	..	..	..	..	..

APPENDIX 49.33 (Contd.)

1	10	11	12	13	14	15	16	17	18
insecticides (contd.)									
DDVP	..	..	..	..	420	276	..	..	144
monocrotophos	..	..	..	..	410	..	300	..	110
phorate	..	..	..	..	700	..	..	..	700
carbofuran	..	..	..	..	4,120	..	..	..	4,120
fungicides									
copper oxychloride	50	500	neg(3)	730	3,650	2,284	..	..	1,366
zineb	..	890	..	710	9,600				
maneb	..	..	..	320	320				
martozeb	..	..	..	270	2,360	4,250	..	..	10,490
ziram	..	..	..	200	1,230				
thiram	..	..	..	..	1,230				
organomercurials	0·1	1·6	neg(0·01)	..	28	111	..	..	..
sulphur (wettable & dust)	..	..	..	10	6,280	8,000	..	..	..
hinosan	..	..	..	..	670	..	..	..	670
duter	..	..	..	15	15	..	..	..	15
brestan	..	..	..	15	15	..	..	..	15

APPENDIX 49.33 (Contd.)

1	2	3	4	5	6	7	8	9
antibiotics								
streptocycline	9	..	..	..	..	..	..	..
acaricides								
tedion	..	..	..	..	..	..	..	..
kelthane	..	..	..	..	..	..	..	..
ethion	..	..	..	..	..	..	..	..
weedicides								
2,4-D	990	860	80	..	100	..	130	..
propanil	2,360	..	..	..	..	..	..	..
alachlor	..	..	..	..	..	..	..	30
MSMA/DSMA	..	..	..	..	..	..	..	..
nitrofen (tok)	..	..	..	..	..	..	..	..
simazine	..	..	110	..	..	..	130	..
atrazine	..	..	90	..	90	..	210	..
diuron	..	..	..	..	..	..	..	140
rodenticides								
zinc phosphide	..	..	..	..	..	..	..	..
sodium cyanide	..	..	..	..	..	..	..	..
nematicides								
DD/DBCP	..	..	..	..	..	..	..	..

APPENDIX 49.33 (Concld.)

1	10	11	12	13	14	15	16	17	18
antibiotics									
streptocycline	..	..	..	..	9	0·5	..	..	8·5
acaricides									
tedion	..	..	..	75	75	..	..	..	75
kelthane	..	..	..	10	10	..	..	..	10
ethion	..	..	..	50	50	..	..	..	50
weedicides									
2, 4-D	..	..	..	..	2,160	1,935	..	..	225
propanil	..	..	..	..	2,360 }				
alachlor	..	150	..	..	180 }	..	4,400	..	..
MSMA/DSMA	..	..	..	440	440	..	1,000	..	..
nitrofen (tok)	..	120	..	..	120	..	1,500	..	..
simazine	..	..	..	..	240	..	..	..	240
atrazine	..	..	..	..	390	..	..	..	390
diuron	..	..	..	..	140	..	..	..	140
rodenticides									
zinc phosphide	..	..	..	..	300	300	216	..	..
sodium cyanide	..	..	..	..	..	..	..	..	..
nematicides									
DD/DBCP	..	..	..	..	200	..	..	..	200
					105,782				32,162·5

NOTE : Data under columns 15, 16 and 17 have been obtained from 'Guidelines for Industries' 1974-75. Government of India, Ministry of Industrial Development, New Delhi, p. 233.

APPENDIX 49.34

(Paragraph 49.8.1)

Raw Materials for 1000 kg of Insecticides[1]

Name of the Insecticide	Main raw materials	Quantity for 1 ton
1	2	3
		Kg.
BHC	1. benzene	300
	2. chlorine	800
DDT	1. chloral	400
	2. chlorobenzene	450
Phosphamidon . . .	1. dichloroacetamide	700
	2. trimethylphosphite *	415
DDVP	1. chloral	500
	2. trimethylphosphite *	500
Copper sulphate . .	1. copper	240
	2. sulphuric acid	400
Copper oxychloride . .	1. copper	580
	2. hydrochloric acid	400
Nickel chloride . . .	1. nickel*	250
	2. hydrochloric acid	1000
2, 4-D-acid . . .	1. 2, 4-dichlorophenol	800
	2. Monochloroacetic acid	450
Aluminium phosphide .	1. aluminium	500
	2. phosphorus red	550
Zinc phosphide . .	1. zinc powder	800
	2. red phosphorus	250
Thiram	1. carbon disulfide	500
	2. dimethyl amine *	500
	3. sodium hydroxide	300
Ziram	1. carbon disulfide	500
	2. demethyl amine *	250
	3. zinc chloride	600
	4. sodium hydroxide	300
Thiocarbamate . . .	1. carbon disulfide	550
	2. ethlene diamine *	225
	3. zinc chloride	950
	4. sodium hydroxide	300

APPENDIX 49.34 (Contd.)

1	2	3
		Kg.
Endrin	1. cyclopentadiene *	250
	2. hexachlorocyclopentadiene	800
	3. vinyl chloride *	200
Aldrin	1. cyclopentaoiene *	250
	2. acetylene	100
	3. hexachlorocyclopentadiene *	800
Chlordane . . .	1. cyclopentadiene*	250
	2. hexachlorocyclopentadiene *	800
	3. chlorine	100
Toxaphene . . .	1. camphene	400
	2. chlorine	1,400
Phorate	1. phosphorus pentasulfide	1,000
	2. ethanol	400
	3. formaldehyde	200
	4. ethyl mercaptan*	200
Phenthoate . . .	1. L. bromophenylacetic acid*	700
	2. ethanol	150
	3. methanol	100
	4. phosphorus pentasulfide	700
Tetradifon . . .	1. 2, 4-5-trichloro phenyl sulfonyl chloride*	1,000
	2. chlorobenzene	350
Dicofol	1. DDT	100
	2. chlorine	100
	3. sulfuric acid	300
	4. paratoluenesulfonic acid	500
Carbamate . . .	1. naphthol	800
	2. methylamine*	100
	3. phosgene, or	500
	4. MIC	320
Carbofuran . . .	1. MIC	290 (370)
	2. catechol*	1,160 (2,210)
	3. methallyl chloride*	950 (1,810)

APPENDIX 49.34 (Concld.)

1	2	3
		Kg.
Endosulfan . . .	1. hexachlorocyclopentadiene*	700
	2. 1,4-butene-diol*	250
	3. thionyl chloride	300
Paraquat	1. sodium cyanide*	300
	2. pyridine	970
	3. methyl chloride	660
Furadan	1. catechol*	2,210
	2. methylisocyanate	370
	3. methallyl chloride*	1,810
	4. chloroform	2,200
	5. methyl alcohol	2,000 litre
		Kg.
	6. sodium methoxide	1.105
E. parathion . . .	1. paranitrophenol*	535
	2. phosphorus trichloride	685
M. parathion . . .	1. paranitrophenol*	670
	2. phosphorus trichloride	910
Dimethoate . . .	1. phosphorus pentasulphide	1,000
	2. monomethylamine*	500
Fenitrothion . . .	1. phosphorus trichloride	910
	2. p-nitro meta cresol*	795
	3. phosphorus pentasulphide	700
Malathion . . .	1. phosphorus pentasulphide	500
	2. maleic anhydride*	370
Methyl demeton 50% conc.	1. paranitrometacresol*	1,300
	2. thioalcohol*	397

[1] Fifth Five Year Plan (1974-1979). Report of the Task Force IV on Pesticides. Ministry of Petroleum and Chemicals, Government of India.

* Imported.

APPENDIX 49.35

(Paragraph 49.10.1)

Classification of Chemicals Based on Physical Condition and Grades

Chemicals	Physical condition				Grades			
	% Dust (D)	% Wettable powder (WP)	% Emulsifiable concentrate (EC)	% Granules (G)	Extremely toxic	Highly toxic	Moderately toxic	Slightly toxic
1	2	3	4	5	6	7	8	9
I. Insecticides								
a. chlorinated hydrocarbons								
1. aldrin	2,5	40	30			+		
2. BHC	5,10	50	20	10			+	
3. chlordane	5, 10		20,25,40, 75			+		
4. DDT	4,5,10	25,30,50	25			+		
5. dieldrin	1·5	50	18		+			
6. endosulfan	2,4		35	4,5		+		
7. endrin	1,2		20,25	2	+			
8. heptachlor	3,5,6	25	20			+		
9. lindane	0·65,1·3	5,6·5,7	20	5,6		+		
10. toxaphene	10		60, 80			+		

APPENDIX 49.35 (Contd.)

1	2	3	4	5	6	7	8	9
I. insecticides—*contd.*								
b. organophosphates								
11. cytrolane			25		+			
12. DDVP			100			+		
13. diamethoate			30			+		
14. disyston				5	+			
15. fenitrothion	5		50, 100	5		+		
16. formothion			25			+		
17. malathion	2, 4, 5	5, 25	4, 40, 50, 75				+	
18. metasystex			20, 25			+		
19. monocrotophos			20, 60			+		
20. (a) parathion (ethyl)			46·7, 50		+			
(b) parathion (methyl)	1,2,20		50		+			
21. phorate				10	+			
22. phosphamidon			100			+		
23. quinalphos			25	5				
24. thiometon			25			+		
c. miscellaneous new insecticides								
25. aldicarb				10	+			
26. azinphos methyl					+			
27. carbofuran				3	+			
28. carbaryl	2·5, 5, 10	6·5, 50		4		+		
29. chlorfenvinphos			24	10	+			

30. dicrotophos			90	+		
31. EPN			45	+		
32. methomyl		50		+		
33. padan	2	50			+	
34. phenthoate			50		+	
35. phosalone			35		+	
36. phosvel		50	3		+	
37. vamidothion			40		+	
II. fungicides						
a. metallic salts						
38. copper oxychloride	12	50				+
39. copper sulphate		50			+	
40. nickel chloride	23-25% water soluble crystalline form					
b. non-metallic salts						
41. sulphur dust	7,90				non toxic	
42. sulphur wettable		80			non toxic	
c. organomercurials						
43. ethylmercury chloride	1% dry seed dressing					
44. (a) ethoxyethylmercury chloride						
(b) methoxyethylmercury						
45. phenylmercury acetate	3-6% concentration					
46. phenylmercury chloride					+	
47. phenylmercury salicylate				+	+	

APPENDIX 49.35 (Contd.)

1	2	3	4	5	6	7	8	9
II. fungicides—(Contd.)								
d. thiocarbamates								
48. maneb	8	80						+
49. mancozeb		75						+
50. zineb	10, 15, 25	65, 75, 78						+
e. dithiocarbamates								
51. ferbam		75, 76					+	
52. thiram	75	75, 80				+		
53. ziram		75, 80					+	
f. other miscellaneous fungicides								
54. benlate			50					+
55. fentiazon					+			
56. fentin acetate		60				+		
57. fentin hydroxide		20				+		
58. hinosan	2		50			+		
59. PCNB	20	75						+
60. plantvax		75					+	
61. vitavax		75					+	
III. weedicides								
a. aceticacid derivatives								
62. (a) 2, 4-D amines			50, 75			+		
(b) 2, 4-D sodium		80, 90-95				+		
63. 2, 4, 5-T+ 2, 4-D ester			70			+		

b. amide derivatives							
64. alachlor		50	10			+	
65. butachlor		50	5				
66. propachlor	65					+	
67. popanil		35		+		+	
c. arsonate derivatives							
68. DSMA		23			+		
69. MSMA		23			+		
d. other derivative							
70. nitrofen		25	8			+	
e. propioicacid derivative							
71. dalapon	80					+	
f. pyridine derivative							
72. paraquat		20			+		
g. thiocarbamate derivative							
73. triallate		50				+	
h. experimental & miscellaneous herbicides							
74. ammonium sulphamate						+	
75. banvel						+	
76. probe							
77. trifluralin		48					+

24 3 Deptt of Agri/76

APPENDIX 49.35—(Concld.)

1	2	3	4	5	6	7	8	9
III. Weedicides (Contd.)								
78. triazine								
(a) atrazine		50					+	
(b) propazine							+	
(c) simazine		50						+
79. sinbar								
80. sirmate							+	
81. sub ureas								
(a) diuron		80					+	
(b) monuron		80					+	
IV. acaricides								
82. ethion			50			+		
83. kelthane			8,18,18·5				+	
84. morestan		25					+	
85. morocide			40			+		
86. omite		30		+	+		+	
87. tedion							+	+
88. trithion	1,2,3	25		5, 10	+			
V. nematocides								
89. DBCP			60			+		
90. DD			100			+		
91. metham N. sodium			40-42% acqueous solution			+		
92. telone						+		
93. terracur				10			+	

VI. antibiotics						
94. aureofungin		1·5				+
95. streptocycline		15	5000 ppm	non toxic		
VII. rodenticides						
96. coumafuryl			+			
97. cynodust	32				+	
98. warfarin		1:9 bait-0·54% water soluble	+			
99. zinc phosphide		1:9 bait	+		+	
VIII. fumigants						
100. aluminium phosphide		3 gms tablet	+			
101. ethylene dibromide		67% phosphine		+		
102. BDCT mixture		3:1				
103. methyl bromide		17 ppm				
IX plant growth regulants						
104. alar		85% WP				+
105. cycocel		50% W/V acqueous solution			+	
106. ethephon		4% W/V WS (acid aster)			+	
107. gibberellic acid					+	
108. maleic hydrazide		25% M/V amine salt solution-40% WP.				+

APPENDIX 49·36

(Paragraph 49·8·2-12)

Name of Plant Protection Chemicals

Common Name	Chemical Name	Other Name
I. Insecticides		
A. Chlorinated hydrocarbons		
1. Aldrin	1, 2, 3, 4, 10-10-Hexachloro-1, 4-4a, 5, 8, 8a hexahydro-1, 4-*endo-exo*-5, 8-dimethano-napthalene.	Aldrex, Aldrosol, Drinox, Octalene, Seedrin.
2. BHC	1, 2, 3, 4, 5, 6, Hexachlorocyclohexane or Benzene hexachloride.	Benzex, Benzichlor, Benzahex, Doi, Dolmix, Gamexane, HCCH, Hexachlor, Hexyclah, Micosane, Soprocide.
3. Chlordane	1, 2, 4, 5, 6, 7, 8, 8-Octachlor-2, 3, 3a, 4, 7, 7a-hexahydro-4, 7-methanoindane.	*Chlordan*, Corodane, Chlorkil, Kypchlor, Ocat. chlor, Ortho-Klor, Synklor, Topichlor 20.
4. DDT	Dichlorodiphenyl Trichloroethane or 1, 1, 1-Trichloro-2, 2-bis (*p*-chlorophenyl) ethane.	Anofex, Dedelo, Didimac, Genitox, *Guesarol* Gesapon, Gesarol, Gyron, Ixodex, Kopsol, Neocid, Penthachlorin, Rukseam, Zerdane.
5. Dieldrin	1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-Octahydro-*exo*-1, 4-erdo-5, 8-dimethanonapthalene.	Alvit, *Dieldrex*, Octalox, Micodiodirin Panoram D-31.
6. Endosulfan	6, 7, 8, 9, 10, 10-Hexachloro-1, 5, 5*a*, 6, 9, 9*a*-hydro-6, 9-methano-2, 4, 3-benzo(e)-dioxa-thiepin-3 oxide.	Chlorthiepin, Cyclodan, Hexasulfan, Insectophene Kop-Thiodan, Malix, Thifor, *Thiodan*, Thimul, Thionex.
7. Endrin	1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-*exo*-1, 4-*exo*-5, 8-dimethanonapthalene.	*Endrex*, Enzex, Hyxadrin, Mendrin, Tafadrin.

8. Heptachlor	1, 4, 5, 6, 7, 8-Heptachloro-3*a*. 4. 7. 7*a*-tetrahydro-4, 7-methanoindene.	Drinox H-34, ***Heptamul***.
9. Lindane	Gamma isomer of 1, 2, 3, 4, 5, 6-Hexachlorocyclohexane.	Gamma-BHC, ***Gammexane***, Gamaphex, Gammaline, Gammex, Lindafor, Lindagam, Lintox, Novigam, Silvanol.
10. Toxaphene	Chlorinated Camphene.	Alltox, clor Chem Th-590, poly chloro-camphene, Phenancide, Phenatox, Strobane-T, Toxakil.
B. Organophosphates		
11. (a) Azinphos (Ethyl)	*O*, *O*-Diethyl-S(4-oxo-3*H*-1, 2, 3-benzotriazine-3 yl-) methyl-dithio Phosphate	***Gusathion A***.
(b) Azinphos (methyl)	*O*, *O*-Dimethyl-S[c-Oxo-1, 2, 3-benzotriazin-3 (4*H*)yl-methyl] phosphorodithioate.	***Guthion***, Carfene, Gusathion M.
12. Chlorfenvinphos	2-chloro-1 (2, 4-dichlorophenyl)-vinyl diethyl phosphate.	***Birlane***, Sapecron, Supona.
13. Cytrolane	2-(diethoxyphosphinylimino)-4 methyl-1, 3 dithiolane.	..
14. Dicrotophos	3-Hydroxy-*N*, *N*-dimethyl-*cis*-crotonamide dimethylphosphate.	***Bidrin***, Carbicron, Ektafos.
15. D D V P	2, 2 dichloro vinyl, *O*, *O*-dimethyl phosphate.	***Dichlorvos***, Dichlorphos, Dedevap, Divipan, Herkol, Mafu, Marvex, Nogos, No-Pest, Nuvan, Oko, Phosvit, Vapona.
16. Dimethoate	*O*, O-Dimethyls-(*N*-methylcarbamoyl methyl) phosphorothioate.	Cygon, Daphene, De-Fend, Fostion MM, ***Rogor***, Roxion, Perfektion, Trimetion.

APPENDIX 49·36—(Contd.)

Common Name	Chemical Name	Other Names
I. Insecticides (Contd.)		
17. Diazinon	*O*, *O*-Diethyl *O*-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate.	*Basudin*, Diazajet, diazide, Diazol, Dazzel, Gardentox, Spectracide.
18. EPN	*O*-Ethyl*O*-*p*-nitrophenylphenyl phosphonothioate.	..
19. Fenitrothion	*O*, *O*-Dimethyl *O*-(4-nitro-*m*-tolyl) phosphorothioate.	Accothion, Folithion, Novathion, Nuvanol, *Sumithion*.
20. Fenthion	*O*, *On*-Dimethyl *O*-[3-methyl-4-(Methylthio) phosphorothioate. ?	*Baytex*, Entex, Lebaycid, Tiguvon.
21. Formothion	*O*, *O*-Dimethyl-*s*-(*N*-methyl-*N*-formyl-carbomoyl-methyl) phosphorodithioate.	Aflix, *Anthio*.
22. Malathion	*O*, *O*-Dimethyl phosphorodithioate of diethyl-mercapto succinate.	Carbofos, Cythion, Emmatos, Fyfanon, Karbofos, Kop-Thion, Kypfos, Malaspray, Malamer-Mercaptothion, Zithiol.
23. Metasystox	*O*, *O*-Dimethyl*O*(and *S*)[2-(ethylthio) ethyl] phosphorothioates I and II.	*Dememton-methyl*.
24. Monocrotophos . . .	3-hydroxy-*N*-methyl-*cis*-crotonamide-dimethyl phosphate.	Azodrin, *Nuvacron*.
25. Menazon	*S*-(4, 6, Diamino-*S*-triazin-2-ylmethyl)*O*, *O*-dimethyl phosphorodithioates.	Azidithion, Saphi-Col, Saphizon, Saphos, *Sayfos*, Sayphos.
26. (a) Parathion (Ethyl) . .	*O*, *O*-Diethyl-*O*-p-nitrophenyl phosphorothioate.	Alleron, Alkron, Bladan, Corothion, Etilon, Ekatox, Folidol, Fosfono, 50, Niran, Orthophos, Panthion, Paramar, *Parathion*, Parawet, Phoskil, Rhodiatox Soprathion, Stathion, Tehiophos.

(b) Parathion (Methyl)	*O, O*-Dimethyl-*O-p*-nitrophenyl phosphorothioate.	*Dalf*, Folidol-M, Metaphos, Metacide—50, Metron, Nitrox-80, PartronM, Takwaisa.
27. Phenthoate	*O, O*-Dimethyl-*S*-(α-ethoxy-carbonylbenzyl)-Phosphorodithioate.	Cidial, Dimephenthoate, *Elsan*, Papthion.
28. Phorate	*O, O*-Diethyl-*S*-(ethylthio)-methyl phosphorodithioate.	*Thimet*, Timet.
29. Phosalone	*O, O*-Diethyl-*S*-[C-Chloro-2-oxobenzoxazolin-3yl) methyl] phosphorodithioate.	*Zolone*.
30. Phosphamidon	2-Chloro-*N, N*-diethyl-3(-dimethoxy-phosphinyloxy) crotonamide.	*Dimecron*.
31. Phosvel	*O*-(4-Bromo-2,5-dichlorophenyl)*O*-methyl-phenyl-phosphonothioate.	Abar, Leptophos.
32. Quinalphos	*O, O*-Diethyl*O*-(2-chinoxalyl)-phosphorothioate.	Bayrusil, *Ekalux*.
33. Thiodemeton	*O, O*-Diethyl *S*-(2-(ethylthio) ethyl) phosphorodithioate.	Disyston, Disulfoton, Dithiosystox, Frumin Al—Solvirex.
34. Thiometon	*O, O*-Dimethy.-*S*-(2-(ethylthio) ethyl) phoshporodithioate.	*Ekatin*.
35. Trichlorphon	Dimethyl (2, 2, 2-trichloro-1-hydroxyethyl) phosphonate.	*Dipterex*, Dylox.
36. Vamidothion	*O, O*-Dimethyl-*S*-(2-c1-methylcarbomyl-ethyl) thio) ethyl) Phosphorodithioate.	*Kilval*, *Vamidothion*.

APPENDIX 49·36—(Contd.)

Common Name	Chemical Name	Other Names
I. Insecticides (Concld.)		
C. Carbamates and *their Thio salts*		
37. Carbaryl	1-Naphthyl *N*-methylcarbamate.	Hexavin, Karbaspray, Ravyon, Septene, *Sevin*, Tricarnam.
38. Carbofuran	2, 3-Dihydro-2,2dimethyl-7-benzofuranylmethyl carbamate.	*Furadan*
39. Methomyl	*S*-Methyl-*N*-(methylcarbamoyl)oxy)thio acetimidate.	*Lannate*.
D. Others		
40. Aldicarb	2-Methyl-2(methylthio) Propionaldehyde-*O*-(metnylcarbamoyl)-oxime.	Ambush, *Temik*.
41. Nicotine	(*S*),-3-(1-Methyl-2 pyrrolioyl) Pyridine.	..
42. Padan	1, 3-Bis (Carbamoylthio)-2-(*N*, *N*-dimethylamino) propane.	*Cartap*.
43. Telodrin	Minimum of 82% isobornylthio cyanoacetate+ 18% (Maximum) of active terpene.	*Isobenzan*.
44. Thanite	Isobornyl thiocyanoacetate, 82%; other related terpenes, 18%.	..
II. Fungicides		
A. Metallic salts		
45. Copper Oxychloride . . .	Basic cupric chloride.	Basic Copper Chloride, Coprantol, Blitox, Blue *Copper* 50, Colloidex, Coxysan, Cupramar, Cupric chloride, Cupravit, Cuprox, *Fytolan*.

46. Copper Sulphate	Cupric Sulphate Pentahydrate	Blue Stone, *Blue Vitrol*, Blue Copperas.
47. Cuprous Copper oxide	Cupric oixde (CuO), Cuprous oxide Cu_2O.	Copper-Sardez, Coppesan, Fungimar, Fytomix, Perenox, Yellow Cuprocid.
48. Nickel Chloride	$NiCl_2$	..
B. Non-metallic Salts		
49. Sulphur dust	..	Brim stone, *Cosan*, sofril.
50. Sulphur colloidal	..	Sulkol.
51. Sulphur wettable	..	Cosan, Hexasul, Thiovit, Sulkol, Sultof, Solbar, Spersul, Spitox, Sulfex.
C. *Organomercurials*		
52. Ethylmercury chloride	C_2H_5HgCl	*Ceresan*, Granosan.
53. Methoxy ethyl mercury-Chloride	$C_2H_3OC_2H_4HgCl$. About 2 to 6% mercury equivalent.	Aretan, Agallol (3% mercury equivalent), Agallolforte (6% mercury equivalent), Baytan, *Ceresanwet*, Cereresan-Universal-Nasbeize (2·5% to 3·5% mercury—equivalent) Tayssato (2·2% Dust, 1·9% liquid).
54. Phenyl mercury chloride	C_6H_5HgCl.	Stopspot.
55. Phenyl mercury acetate	$C_6H_5Hg\,OOC\,CH_3$	*Agrosan G. N.* Ceresan—Gallotox, Hongnien, Liquiphene, Mersolite, *PMA*, Phenmad, Phix, Shimmerex.

APPENDIX 49.36—(Contd.)

Common Name	Chemical Name	Other Names
II. Fungicides (Contd.)		
56. Phenyl mercury salicylate	C_6H_4OH COO Hg C_6H_5	Merculine, Mercusol.
D. Carbamate		
57. Benlate	Methyl-1 (butyl carbamoyl)-2-benzimidazole-carbamate.	*Benomyl.*
E. Thiocarbamates		
58. Maneb	Manganese ethylehe-1, 2-bis-dithiocarbamate.	Chloroble M, *DithaneM*-22, Kypman 80, Maneba, Manesan, Manzate, Manzate D, Sopranebe Trimangol,
59. Mancozeb	Coordinate product of Zinc ion and Manganese Ethylene-bisdithiocarbamate.	*Dithane M*- 45, Fore
60. Nabam	Disodium ethylene-1, 2 bisdithio Carbamate.	Chem Bam, Dithane D-14, DSE Parzate, Spring-Bak.
61. Zineb	Zinc ethylene bisdithio Carbamate.	Aspor, Chem Zineb, *Dithane Z*-78, Hexathane, Kypzin, Lonacol, Pemosol, 2 Forte, Parzate C, Polyram Z, Tiezene, Tritoftorol, Zebtox, Zidan, Zinosan.
F. Dithiocarbamates		
62. Ferbam	Ferric dimethyl dithiocarbamate.	Fermate, Ferberk, Hexaferb, Trifungol.
63. Thiram	Bis (dimethylthio Carbamoyl) disulfide; or tetra-methylthiuram-disulfide.	Arasan, Fermide 850, Hexathir, Mercuram, Nomersam, Polyram-ultra, Pomarsol, fote, Spotrete, Tersan, *Thimer*, Thiride, Thiotex,

		Thiramad, Thirasan, Thylate, Tirampa, TMTDS, Trametan, Tripomol, Tuads, Vancide, TM-95.
64. Ziram	Zinc dimethyldithiocarbamate.	*Cuman*, Fukiasin, Hexazir, Mezene, Pomarsol Z forte, Tricarbamix Z, Triscabol, Zerlate, Zirberk, Ziride, Zitox.
C. Others		
65. Fentin Acetate . . .	Triphenyltin Acetate.	*Prestan*. Phentin acetate
66. Fentin Hydroxide . . .	Triphenyltin hydroxide.	TPTH, *Du-Ter*.
67. Captan . . .	*cis*-N-[(Trichloromethyl) thio)]-4-Cyclohexene-1,2 dicarboximide.	Merpan, Orthocide.
68. Fentiazon	3-Benzylideneamino-4-phenylthiazo line-2-thione.	*Celdion*.
69. Hinosan	O-Ethyl-*S*, *S*-diphenyl-ditho asphosphate.	Edifenphos.
70. Karathane	2-(1-Methyl-n-hepthyl)-4-6-dimethyl (Crotonate with its isomer 4-(1-methyl nyheptyl) 2, 6dinitrophenyl Crotonate.	Arathane, Dinocao, Iscothane, Mildex.
71. PCNB	Pentachloronitrobenzene	Avicol, Botrilex, *Brassicol*, Folosan, Tritisan, Terrachlor, Tilcarex,
72. Plantvax	Dioxide of Vitavax.	Oxycarboxin
73. Vitavax	5, 6-Dihydro-2-methyl-1, 4-Oxothiin-3-Carboxanilide.	Carboxin.

APPENDIX 49.36—(Contd.)

Common Name	Chemical Name	Other Names
III. Weedicides		
A. Acetic Acid Derivatives		
74. 2, 4 D	2, 4-Dichlorophenoxy acetic acid.	Amoxone, Chloroxone, Crop Rider, Dacamine, Ded-Weed, Esteron, Pennamine-D, Salvo, Tributon, Weedone.
75. 2, 4, 5-T	2, 4, 5 Trichlorophenoxyacetic acid.	Ded-Weed Brush Killer, Esteron 245 Concentrate, Fence Rider, Inverton 245 Line Rider, Reddon.
B. Amide Derivatives		
76. Alachlor	2-Chloro-2′, 6′, diethyl-N-(methoxymethyl)-acetanilide.	*Lasso*, Lazo.
77. Butachlor	2-Chloro-2′6′, diethyl-*N*-(butoxymethyl)-acetanilide.	*Machete*.
78. Propachlor	2-Chloro-*N*-Isopropyl acetanilide.	*Ramrod*.
79. Propanil	3-4-Dichlorophenylpropionanilide.	Chem Rice, DPA, *Stam* F-34, Surcopur.
C. Areonate Derivatives		
80. DSMA	Disodium methanearsonate.	Ansar, 8100, Ansar DSMA liquid, Arrhenal, Arsinyl, Crab-E-Rad, Dal-E-Rad 100, Ditac, DMA, DMA 100, Methar, Sedar, Weed E-Rad.
81. MSMA	Monosodium methanearsonate.	Ansar 170, H.C., Bueno, *Ansar* 529.
D. Ether Derivative		
82. Nitrofen	2, 4-Dichloro phenyl *P*-Nitrophenyl ether.	*Tok*.

E. Fatty Acid Derivatives		
83. Dalapon	**2, 2-Dichloropropionic Acid Sodium salt.**	**Ded-Weed, *Dowpon*, Gramevin, Radapon, Unipon.**
84. TCA	**Sodium Trichloroacetic acid.**	**Sodium TCA.**
F. Pyridyl Derivatives		
85. **Diquat**	6, 7-Dihydrodipyridol (1, 2′-a : 1′-*C*) pyrazidinium dibromide.	**Aquacide, Dextrone, Reglone.**
86. **Paraquat (dichloride salt)**	1, 1′-Dimethyl-4′, 4-bipyridinium ion.	Gramoxone, Weedol.
87. **Paraquat (dimethyl sulphate)**	1, 1′-Dimethyl-4, 4′-bipyridinium ion.	***Dual paraquat.***
G. Thiocarbamate Derivatives		
88. Eptam	*S*-Ethyl-*n*, *n*-dipropylthio-carbamate.	EPTC.
89. Tillam	*S*-Propyl, butylethylthio Carbamate.	***Pebulate*, PEBC.**
90. Triallate	*S*(-2, 2, 3-Trichloroallyl) diisopropylthiocarbamate.	Avadex BW, Far—Go.
H. Triazides		
91. Atrazine.	2-Chloro-4-(ethylamino)-6-(isopropylamino)-S-triazine.	Atrex, Gesaprim, Primatol A.
92. Lambast.	2, 4-Bis [(3-methoxypropyl) amino)]-6-methylthio-*S*-triazine.	..
93. Prometon	2, 4-bis (Isopropylamino)-6-methoxy-*S*-triazine.	Gesafram, Pramitol, Prometone.
94. Prometryne	2, 4-bis (Isoprophylamino)-6-methylthio-S-triazine.	Caparol, Gesagard, Primatol Q.

APPENDIX 49·36 (Contd.)

Common Name	Chemical Name	Other Name
III. Weedicides (Contd.)		
95. Propazine	2-Chloro-4, 6-bis(isopropylamino)-*s*-triazine.	Gesamil, Milogard, Primatol P.
96. Simazine	2-Chloro-4, 6-bis (ethylamino)-*s*-triazine.	Gesatop, Princep, Primatol S.
I. Others		
97. Ammonium Sulphamate	$H_2N SO_2 O N H_4$	Ammate, Amcide, AMS.
98. Borax	Sodium tetraborate decahydrate ($Na_2B_4O_7 . 10H_2O$).	Borascu, Gerstley Borate, Neobor, Tronabor.
99. Banvel D	3, 6-Dichloro-*o*-anisic acid.	Benex, *Dicamba*, Medibeb.
100. Banvel T	3, 5, 6-Trichloro-*o*-anisic acid.	Metriebn, *Tricamba*.
101. PCP	Pentachlorophenol.	Dowicide, 7, Penchlorol, Penta, Sinituho, Weedone.
102. Sinbar	3-*tert*-Butyl-5-chloro-6-methyluracil.	*Terbacil*.
103. Sirmate	3, 4 and 2, 3-Dichlorobenzyl *N*-methylcarbamate.	*Rowmate*.
104. Trifluralin	*a, a, a*,-Trifluoro-2, 6-dinitro-*N, N*-dipropyl-*p*-toluidine.	*Treflan*, Elancolau
105. Tenoranon	3-[p-(p-Chlorophenoxy)-phenyl]-1, 1-dimethylurea.	Chloroxuron.
J. Sub-Areas		
106. Diuron	3-(3, 4-Dichlorophenyl)-1, 1-dimethylurea.	DMU, Mermer.
107. Monuron	3-(p-Chlorophenyl)-1, 1-dimethylurea.	Chlorfenidim, Telvar.

IV. Nematicides		
108. D. B. C. P.	1,2-Dibromo-3-chloropropane.	*Dibromochloropropane*, Fumazone, *Nemafume*, Nemagon.
109. D. D.	1,2,-Dichloropropane; and1, 3 Dichloropropene	Nemafene.
110. Methan N Sodium	Sodium *N*-methyldithiocarbamate.	*Metham*, Trimaton, VPM, *Vapam*.
111. Telone	1, 3 Dichloropropene.	*Dichloropropene*.
112. Terracur	5-Carboxymethyl-3-methyl-2*H*-1, 3, 5-thiadiazine-2-thione.	Thiadiazinthion.
113. Terracur P	*O,O*-Diethyl*O* [4-(methylsulfinyl) phenyl] phosphorothioate.	*Dasanit*, Fensulfothion.
V. Acaricides		
114. Azobenzene	Diphenyl diimide.	*Azobenzide*.
115. Chlorobenzilate	Ethyl 4, 4′-dichlorobenzilate.	Akar, Acaraben, Folbex, Kop-Mite, *Benzilan*.
116. Ethion	*O, O, O, O*-Tetraethyl *S, S*-methylene bis-phosphorodithioate.	Nialate.
117. Kelthane	1, 1-Bis (chlorophenyl)-2, 2, 2-trichloroethanol	Acarin, *Dicofol*.
118. Morestan	6-Methylquinoline-2, 3-diyl dithiolocarbonate.	Chinomethionate, Forstan, Oxythioquinox, Quinomethionate.
119. Morocide	2-*sec*-Butyl-4, 6 dinitrophenyl-3-methyl-2-butenoate.	Acricid, Ambox, *Binapacryl*, Dinoseb methacrylate, Endosan.
120. Omite	2-(*p-tert*-Butylphenoxy) cyclohexyl-2-propynyl sulfite.	

APPENDIX 49·36 (Contd.)

Common Name	Chemical Name	Other Name
V. Acaricides (Contd.)		
121. Tedion	*S*-*p*-Chlorophenyl2, 4, 5-trichlorophenyl sulfone.	*Tetradifon.*
122. Trithion	*S*-[(*p*-Chlorophenylthio)methyl)],*O O*-diethyl-phosphorodithioate.	*Carbophenothion,* Dagadio, Garrathion
VI. Antibiotics		
123. Aureomycin	Chlortatracycline.	*Acronize.*
124. Terramycin	Oxytetracycline	Biostat PA.
Stretpocycline		
125. Streptomycin	Streptomycin(sulphate or nitrate).	Agrimycine, Agri Strep.
Others		
126. B L A-s	Blasticidin-*S* benzylaminobenzen-sulfonate.	*Blasticidin.*
127. Kasumin	D-3-*O*-[2-amino-4-[(1-carboxyiminomethyl) amino]-2, 3, 4, 6-tetradeoxy-*L*-D-arabinoh-exopyranosyl]-D-chiro-inositol.	*Kasugamycin.*
VII. Rodenticides		
128. Barium Carbonate	$BaCO_3$	
129. Coumafuryl	3(*a*-Acetonylfurfuryl)-4-hydroxycoumarin.	*Fumarin.*
130. Cynodust	Calcium cyanide, Sodium cyanide.	
131. Strychnine hydrochloride		
132. Warfarin	3-(*a*-Acetonylbenzyl)-4-hydroxycoumarin.	*Coumafene,* Kypfarin, Zoocoumarin, Ratox,
133. Zinc phosphide	Zn_3P_2	

VIII. Fumigants		
134. Aluminium Phosphide	AlP	*Phostoxin. Celphos*
135. Ethylene Dibromide	1,2-Dibromoethane.	Bromofume, *Celmide*, Dowfume, W-85, Kop-Fume Nephis, Soilbrom 85.
136. Ethylene Dichloride	1,2-Dichloroethane.	EDC
137. E D/CT	Mixture of Ethylene Dichloride & Carbon Tetrichloride.	
IX. Plant growth regulants		
138. Alar	Succinicacid 2,2 dimethyl-hydrazide.	B-Nine.
139. Cycocel	(2-Chloroethyl)trimethylammonium chloride.	Chlormequat chloride.
140. Ethephon	2-(Chloroethyl)phosphonic acid.	*Ethrel.*
141. Gibberellic Acid	2,4a, 7, Trihydroxy-1-methyl-8-methylenegibb-3-ene-1, 10 Carboxylic acid-1......4 lactone.	Activol, Berelex, *Gibberellin*, Gibrel, Gib-sol, Gib-Tabs, Grocel, Pro-Gibb.
142. Maleic hydrazide	1,2-Dihydropyridazine-3, 6-dione.	KMH, Maintain 3, Retard, Slo-gro, Sprout-stop, Sucker-Stuff, Super Sucker-Stuff, Vondalhyde.

NOTE:—In column 'Other names' most common names are underlined.

50

FARM POWER

1 INTRODUCTION

50.1.1 The power required to operate implements and tools for performing various farm operations comes from human labour, draught animals and machines. The precise requirement of this power for achieving satisfactory level of production varies from country to country; and within a country from region to region, depending upon a number of factors like climate, soil and other endowments. The experience of both developed and developing countries has been that there is a definite and positive relation between farm power availability and farm productivity. India has been dependent mainly on bullock power for farm operations. However, of late the demand for increased farm production and application of improved technology have necessitated a judicious adjustment between bullock and machine power in such a manner that large scale introduction of machine power does not come in the way of progress towards the goal of full employment. In this chapter an attempt is made to indicate the present availability of farm power and the major operational constraints that have some bearing on farm productivity. We have also outlined the requirements of farm power by the turn of the century keeping in view the broad dimension of crop production including fodder cultivation. Power requirements of dairying in our view are mostly confined to electricity. It is expected that with the implementation of programmes for expansion of electric power these needs would be adequately met. The power needs of fishery and forestry are of a specialised nature and are duly considered in relevant chapters. Considerable thought has been given to the likely gap in farm power needs and the possibility of bridging the same with farm machinery particularly tractors and power tillers. Related issues like arranging for the manufacture of farm machinery, organising an efficient net-work of maintenance and repair facilities and providing adequate research and administrative support have also been dealt with in this chapter. The present role

of agro-industries corporations in regard to farm machinery has been reviewed in this context and we have suggested some re-orientation in their activities.

2 FARM POWER AND PRODUCTIVITY

Source of Farm Power in Different Countries

50.2.1 There are extreme examples available of the use of power in many countries. In equatorial Africa, 99 per cent of power for farming is even now derived from human effort. The studies carried out in 1969 show that in Savannah areas of Africa, labour is the principal constraint and all attempts are being made to maximise the returns to the unit of labour rather than unit of land. The other extreme is fully mechanised farming as observed in some of the western countries. In 1968, the use of tractor power in the USA was 1.40 hp/ha and the involvement of men was 0.03 (man unit) per hectare of cropped area, whereas in Japan the respective involvement was 3.50 hp/ha and 2.04 (man units) per hectare.[1] The distinction in Japan's case is that, despite the involvement of more tractors, the number of men involved in farming is also quite high. This is pertinent to our conditions, where a debate has been going on regarding the adverse effect of mechanisation on employment opportunities. Japanese people have a desire to increase their income through farming; at the same time they wish to enjoy greater leisure and cherish to educate their children. All these aspirations drive them to take to more and more mechanisation. Between 1955 and 1966, their main dependence was on power tiller for all operations like land preparation, pest control, pumping water and transportation. Since 1967, the use of rice planters and combines is also getting popular.

50.2.2 In some hilly and inaccessible areas of the country farm power needs even today are met mainly from human labour. Small vegetable growers whose holdings are mere fractions of a hectare also rely on manual power for all kinds of farm operations. But for these exceptions bullocks dominate the agricultural scene. The beginning towards farm mechanisation was made in the twenties in the erstwhile Bombay Province where tractors were introduced primarily for deep ploughing and weed eradication. Mechanisation of water lifting for irrigation was also attempted at about the same time on a limited

1. 1968. The State of Food and Agriculture : Rome, FAO, UN.

scale in the Indo-Gangetic plains. The Royal Commission on Agriculture (1928) stated that tractors should be used only on large farms and in such situations where deep tilling was considered necessary. The Commission also emphasised the need for using machine power for pumping water and carrying out well boring operations. Since then there has been an awareness of the need for mechanisation in certain areas and for specific farm operations. During the war period, high priority came to be assigned to minor irrigation under the Grow More Food Campaign which gave a boost to mechanisation of irrigation. The number of tractors in the country which was just 5,000 in 1947 increased to 170,000 by 1972. However, considering the country's crop area the progress seems to be rather slow. Number of power sprayers and dusters in use was 243,000 according to the Livestock Census of 1972[1]. A working Group ofthe Planning Commission on Agricultural Machinery Industry reported[2] that the number of power tillers was about 10,000. This machine was introduced in the country in 1965 initially through import from Japan and thereafter through indigenous production with Japanese collaboration. It has not really caught up in India though studies in Pakistan have indicated that a power tiller of 10 hp capacity is better suited and is more economical than other machines under their conditions. The real progress has been in the case of diesel engines and electric motors used for irrigation; their number according to Livestock Census 1972 was around 2.58 million giving an average distribution of 18 pieces per 1000 hectares of crop area. Compared with this the distribution of tractors is just about 1.2 and that of power sprayers and dusters 1.7 per 1000 hectares.

Indian Farm Power Spectrum

50.2.3 A study was undertaken within the Commission to assess the present status of power spectrum in India in detail. The components of power considered in this study are those originating from human, animal, mechanical and electrical sources. The source of data for human power is the 1971 Population Census. Only the work force in the age group 15-59 engaged in crop production and allied pursuits has been considered for the purpose. Data on livestock and farm machinery have been collected from the States and pertain to Livestock Census 1972. For the sake of calculations, the following

1. Data obtained from State Governments.

2. 1973. Report of the Working Group of the Task Force (1) on the Agricultural Machinery Industry, p. 26, New Delhi. Planning Commission, Government of India.

horse power equivalents have been assumed for various components, the basis of which has been explained in Appendix 50.1.

power component	hp	power component	hp
man	0·07	power sprayer or duster	2·00
woman	0·05	diesel engine	7·00
bullock/buffalo	0·40	electric motor	6·00
camel	1·00	miscellaneous like power crusnes and threshers	6·00
tractor	25·00		
power tiller	7·00		

50.2.4 The attention in the present study has been confined to operations which are of direct consequence in crop production and harvest and post-harvest operations. Tractors are capable of being used in preparatory tillage, interculture, water lifting, plant protection, harvesting and threshing. However, at present they are used mainly for preparatory tillage. Rest of the time, either they remain idle or are used in transportation jobs. Owing to this reason, only 50 per cent of the tractor power is assumed to be utilised in farm operations for the present purpose. For human and animal power, an allowance of 20 per cent has been made for extra-farm activities, and therefore, this proportion is excluded from consideration. The availability of power for agricultural operations has been calculated for all the districts of the country on the basis outlined in this paragraph. The area considered is the net sown area between the years 1968-69 and 1970-71. The total availability of power from human labour, draught animals and machines is presented in Appendix 50.5—Map I. In addition, the contribution coming forth only from mechanical and electrical power has been shown in Appendix 50.5—Map II. The basic data used in the preparation of these maps are given in Appendix 50.2. A summary table indicating farm power availability in 1971 is presented below:—

source of power	number available (million)	hp/ha	percentage contribution
human labour	87·4	0·04	11·6
draught animals	63·3	0·18	50·8
irrigation pumps	2·41	0·11	31·6
tractors and power tillers	0·07	0·01	3·8
other machinery	0·34	0·01	2·2

50.2.5 Main findings of the study are the following:—

(i) Average farm power availability in the country from all sources was 0.36 hp per hectare in 1971. Over 62 per cent of it was contributed by human labour and draught animals and the remaining 38 per cent by farm machinery. The share of tractors in the latter was just about 4 per cent while pump sets had a much larger share of 32 per cent.

(ii) The power position from all the sources is that 53 per cent of the districts have a power availability of less than 0.40 hp/ha. Another 33 per cent of the districts lie in the range 0.40—0.59 hp/ha. Thus, nearly 86 per cent of the districts have a power availability of less than 0.60 hp/ha. There are only 43 districts out of a total of 317 considered, which lie at or above 0.60 hp/ha range. Out of these, there are only 20 which have a power availability of 0.80 hp/ha or more. Their distribution is as follows:

9 in Punjab, 3 in Tamilnadu, 2 each in Andhra Pradesh and Karnataka and 1 each in Gujarat, Uttar Pradesh and Himachal Pradesh.

(iii) The machine power is below 0.20 hp/ha in 79 per cent of the districts and another 12 per cent of the districts lie in the range 0.20 — 0.39 hp/ha. Thus, there are only 9 per cent of the districts which utilise machine power of 0.40 hp/ha or above, their distribution in different States is indicated below:

State	number of districts with hp/ha range of		
	0·40—0·59	0·60—0·79	0·80 and above
Punjab	1	2	7
Haryana	1	1	..
Uttar Pradesh	2	..	..
Gujarat	3	.	
Karnataka	1	-	..
Andhra Pradesh	1	-	..
Tamil Nadu	4	..	..
total	13		

Macdine power is most conspicuous in Punjab. The other areas where machine power is conspicuous are Haryana, Uttar Pradesh, Gujarat, Karnataka, Andhra Pradesh and Tamil Nadu.

Crop Yields and Power

50.2.6 A study on relationship between the yield and power per hectare was conducted in the late sixties by the President's Science Advisory Committee (USA).[1] The average aggregate yield obtained from major crops was plotted against the power in hp required per hectare based on the data collected from various countries of Asia (excluding Mainland China), Africa, Oceania, Latin America, North America and Europe. Some of the important countries included were the UAR, Israel, United Kingdom, India, Tiwan, Japan and USA. The crops considered were cereals, pulses, oilseeds, sugar crops (raw sugar), potatoes, cassava, onions and tomatoes. The graph prepared out of the data considered gives the following relationship between the power used in hp/ha and yield:

power hp/ha	yield tonne/ha	yield to hp ratio
0·13	0·8	6·2
0·16	1·0	6·3
0·24	1·5	6·3
0·37	2·0	5·4
0·53	2·5	4·7
0·87	3·0	3·4
1·37	4·0	2·9
1·74	5·0	2·9
2·05	6·0	2·9

It should be noted that the rate of increase in yield per hp shows a gradual decline and attains a constancy beyond 0.87 hp. Therefore, it has been concluded in the study that the power range for satisfactory yields should lie between 0.5 and 0.8 hp/ha. It is also pointed out therein that timeliness in seed bed preparation is not that much important on irrigated lands as on dry lands, because there is scope to stagger the time of sowing owing to the availability of irrigation water at any desired time. Once the sowing gets distributed over a wider span of time, the pressure on power needs gets reduced and this is ascribed as a reason for Taiwan and Egypt to be able to record better standards of yield even though the power utilised in these countries ranges only between 0.3 and 0.4 hp/ha. It is said that over 60 per cent of the cultivated land is irrigated in Taiwan while irrigation in Egypt is hundred per cent. In another study

1. 1967. The World Food Problem, A Report of the President's Science Advisory Committee, Vol. II; 396-492. Report of the Panel on the World Food Supply, Washington, White House.

applicable to equatorial Africa it has been said that the minimum power need lies around 0.5 hp/ha.[1]

50.2.7 The two foreign studies have been mentioned here only for taking note of the trend of thinking in other parts of the world. There is no intention to base the country's requirements on their results. We propose to make an independent assessment of farm power requirements suited to India's own conditions.

3 REQUIREMENTS OF FARM POWER

District Level Studies

50.3.1 Power for farming is needed for various operations commencing with the breaking of new lands for cultivation, soil and water conservation measures, large scale weed eradication operation and then going over to seed bed preparation, sowing, interculture, irrigation, plant protection, harvesting, threshing, processing and transport for marketing etc. A beginning is made for the present with an examination of the existing position of power requirement for crop production and disposal operations. It is assumed that the only sources available to meet the power requirements are human labour and draught animals. Districts have been so chosen as to represent different agro-climatic conditions. These are: Hissar (representing comparatively dry conditions) and Karnal (irrigated & better off district) of Haryana, Bijapur (scanty rainfall conditions) and Kolar (irrigated and better off district) of Karnataka and Burdwan of West Bengal (heavy rainfall area). All major farm operations beginning with land preparation and raising of nursery and ending with marketing in respect of important crops grown in these districts are taken into account. The monthwise position of power needs and availability in the five districts are indicated in Appendix 50.3 — Statements I to III. The study indicates that the power originating from human and animal sources roughly corresponds with the requirements. Even then a deficit is discernible in some of the months; the number of such months is indicated below:

	power human sources	originating from animal sources	both human and animal sources
Hissar	7	..	1
Karnal	6	..	1
Bijapur	8	3	4
Kolar	..	..	..
Burdwan	4	..	1

1. 1969. *Agricultural Mechanization in Equatorial Africa*, Research Report No. 6. A documentary-field study conducted by Michigan State University in cooperation with United States Agency for International Cooperation, Michigan, Agricultural Hall, Michigan University.

In four out of five districts there are indications of shortage of power at the time of sowing and harvesting. This being the position when crop production technology in vogue in these districts is comparatively backward it could be presumed that the imbalance would be further aggravated with widespread adoption of modern practices. The analysis suggests the need for supplemental power, which would be more agriculturally advanced areas.

Draught Animals

50.3.2 It could be seen from Chapter 28 on Cattle and Buffaloes that the population of bullocks and he-buffaloes in 2000 AD will continue to be around the same level as at present, *viz.*, 80 million. Farm management studies carried out in the fifties on the basis of data pertaining to selected districts of Andhra Pradesh, Uttar Pradesh, West Bengal, Punjab, Tamil Nadu and erstwhile Bombay State indicated that on an average a pair of bullocks was capable of managing 3 hectares.[1] Even in 2000 AD, this rate is not expected to be different because the pressure on bullocks due to improved farm technology will be more than at present. However, their efficiency would at the same time be more than that at present because of better breed and health. On this basis, the crop area which could be managed by 40 million pairs of bullocks in 2000 AD will be 120 M ha. As the total net sown area is expected to be 150 M ha it would imply a power gap equivalent to the needs of 30 M ha. Mechanisation has to be thought of for this much of area. It does not, however, mean that any compartmentalisation between the animal and machine power is envisaged. The two will have to be used in combination in a majority of the situations, but for the sake of calculation, a provision for mechanisation will have to be made to meet the farm power requirements of 30 M ha.

50.3.3 It would be clear that bullocks are going to be maintained at the existing level even in 2000 AD. Because of the improvement in their breed, health and consequent vigour, their cost is likely to increase and, therefore, it may not be within the means of an ordinary farmer to purchase them very easily. Even at present, many farmers require loans for purchase of bullocks. In many States, provision has been made for taccavi loans or advances to help farmers in the purchase of bullocks. However, in actual practice, many farmers experience difficulty and do not get the advances to the required extent. There should be a provision for extending loans covering the

1. 1973. Khurso, A. M., The Economics of Land Reform and Farm in India; 50, New Delhi. The Macmillan Co. of India.

full cost of draught animals. Advances should be made available in time and if there are any bottlenecks, the Government should so frame the rules that it becomes easy for farmers to get the advances. Co-operative and commercial banks should also undertake advancing such loans.

Human Labour

50.3.4 Our approach on the matter of involvement of labour force in agricultural operations has already been defined in Chapter 58 on Rural Employment. It has been laid down as an important objective that children should be removed from field work in order to better their prospects through education and training. Better technology and the use of more intensive methods of cultivation than at present would throw open many new opportunities for gainful employment in crop production. Even in the matter of mechanisation, we have preferred a selective approach which does not jeopardise the chances of livelihood to a vast number of agricultural labour. On these considerations it has been envisaged that the total rural workforce would increase from about 139 million in 1971 to about 250 million excluding children by 2000 AD. Out of this total, the number of agricultural workers is expected to be of the order of 175 milion. Assuming that 80 per cent of their time is utilised in farming activities, the number of such persons would stand at about 140 million in 2000 AD which at the rate of 0.06 hp[1] per person would contribute 8.4 million hp to farm power.

Need for Selective Mechanisation

50.3.5 According to Agricultural Census 1970-71, the area under operational holdings of less than 5 ha is about 47 per cent of the total area of 162 M ha that under 5 — 20 ha group about 40 per cent: and under large holdings of over 20 ha 13 per cent. Holdings of less than 5 ha will continue to depend upon bullock power more heavily than other groups, even to an extent of 80 per cent or more. Their only chance of deriving benefit from mechanical power is through custom service and that too for such operations which they can economically afford. This means that about 50 per cent of the cropped area will depend largely on bullock power. The middle group of 5 — 20 ha can afford to take to mechanical and electrical power in an increasing manner both through direct purchase or

1. The rate assumed here is the mean of the rates assumed earlier for man and woman, *i.e.*, 0.07 and 0.05 hp respectively.

custom service; the dependence on bullock power would stand reduced even to half. Operational holdings of greater than 20 ha will hardly depend on bullock power, but its total exclusion is ruled out in their case. Even the highly mechanised farms in west Uttar Pradesh, Punjab and Haryana are found keeping a few pairs of bullock to perform small operations and for meeting emergencies caused due to breakdowns etc. This shows that the bullock and mechanical/electrical power will be complementary to each other. For time bound operations like sowing, specially in dry areas, where it is required to be completed in a short spell when the rain occur and harvesting and threshing, which require to be hastened for saving the produce from thunderstorms and hailstorms or fire hazards every farmer would wish to utilise quicker means. Even poor farmers may not mind paying for tractor service in sowing and harvesting operations if available at reasonable rates. If it were possible to provide community threshing facility in villages, many people will like to choose it. Difficult land shaping and weed eradication operations done on a large scale will certainly require the use of heavy tractors and this will require the involvement not of individuals but of the Government or other organised bodies.

50.3.6 Insofar as men are concerned, they would perhaps continue to perform all operations including tillage, manuring, weeding and plant protection manually in small vegetable holdings or flower gardens owned by *kachhis* or *malis* respectively. In other holdings, as the dependence on mechanical and electrical means increases, the involvement of human power in manual operations would decrease. Farmers would automatically like to free themselves from the tedium of manual operations if they can afford to adopt some automatic means and to that extent mechanisation would be welcome to all. Despite this inherent advantage of removing drudgery and rendering farm operations more effective, there has always been a debate that mechanisation, specially tractorisation, would cause widespread unemployment under the country's conditions. We have viewed this problem with much seriousness and sponsored three separate studies, one each at the National Council of Applied Economic Research, New Delhi, Institute of Economic Growth, New Delhi and Administrative Staff College of India, Hyderabad. It emerges as a common feature that tractorisation displaces mainly bullock labour and its impact on manpower is much less, in some situations the respective displacement being 60 and 15 per cent. We have indicated above that bullocks in India have enough contribution to make despite mechanisation. In fact, we are providing in our calculations only such area for tractors etc. which cannot be covered easily by bullock power. The little displacement of manpower, which is unavoidable in mechanisation

should not be viewed in isolation from the other side that it opens up new avenues like managerial and supervisory jobs on the one side and driving, servicing and maintenance of machines on the other.

50.3.7 It has often been argued in some quarters that tractorisation of farming operations should be encouraged more in the thinly populated areas than in the densely populated ones in order not to deprive agricultural labour of employment. At the same time, these advocates recognise that the peaks of activity are at present concentrated around sowing and harvesting times, which do not allow for continuous employment all through the year. To rectify this situation and reduce dependence on machines, it is suggested by them that the sowing dates be staggered so that harvesting will also then get spread over a much wider period. This suggestion has also been examined by us. At present, Kharif crops are harvested mostly between October 15, and December 15. Time for harvest up to September is not congenial for harvest, because of the possibilities of monsoon rains. Beyond the middle of December, the temperaturs are low and the hours of bright sunshine also get reduced, because of which the weather does not remain congenial for threshing and drying activities. Thus, the time suitable for kharif harvests cannot be earlier than October and later than December, 15. The months of October and November carry the possibility of thundershowers in many parts of the country to varying degree, the chances being more between September 15, and October 15, because of the receding monsoon activity. Therefore, a longer congenial period for kharif harvest is not possible than what the farmers already follow. Insofar as rabi harvests are concerned, the ideal period from the view point of temperature and sunshine cannot be before March. Months of April and May are already being used by farmers for harvesting and threshing activities. Once again, both these months carry the risk of thundershowers including hailstorms. The risk is more in May than in April. Therefore, the ideal time for harvest under the circumstances is afforded only in the month of April. This again limits the chances of making the harvest spread over a wide period than what is the practice today. It is, therefore, obvious that the suggestion for expanding the spectrum of sowing dates is not tenable. Now we proceed to estimate the future requirements of prime movers

Non-Repetitive Needs

50 3.8 Non-repetitive works relate to land development and include such operations as reclamation; levelling; terracing; bunding; eradication on an extensive scale of wild shrubs, trees and even pernicious weeds like *kans* (*Saccharum spontaneum*). These are large scale

operations beyond the reach of individuals and are mostly undertaken by the Governments as a part of official plans. Individuals can get their jobs done on payment through special requests with the Governments or through a few private organised agencies, which operate on a contract basis. We are envisaging a comprehensive development of command areas of various irrigation projects (Chapter 16). Such a development should include construction of watercourses, field channels, field drains where necessary and linking them with connecting drains, farm roads and land formation to suitable slopes. Some of these works will require bulldozers, excavators, motor graders and even comparatively lighter tractors. The area to be covered by 2000 AD in these operations is about 30 M ha. It has been contemplated in Chapter 16 on Command Area Development that a capability of covering 1.4 M ha of area annually has to be built up gradually by 1985 and thereafter the same rate has to be maintained upto 2000 AD. Certain norms of coverage per unit area and time by different kinds of machines needed for command area development have been determined by the Ministry of Agriculture & Irrigation in the Water Utilisation Division. On that basis, the number of machines which will have to be maintained in working order to complete the annual targets upto 2000 AD will be: bulldozers (90-150 hp). 2700; excavators (90-150 hp), 2600; motor graders (90-150 hp), 1800; tractors (50-80 hp), 2300; and tractors (20-50 hp), 7900. In terms of horsepower the contribution of these machines will be of the order of 1.28 million hp if worked out at the mid-point of their capacity ranges.

Tractor Needs in Crop Production

50.3.9 Agricultural tractors are classified as power tiller (2 wheel walky tractor between 5-10 hp range developed in Japan particularly for paddy cultivation), power tiller (4 wheel tractor of 10-20 hp capacity also called as garden tractor), 4 wheel medium tractor of 20-50 hp capacity and 4 wheel heavy tractor of 50-80 hp range. Their involvement in crop production operations for an area equivalent of 30 M ha is fully discussed in Appendix 50.4. A summary of requirements is presented below:

tractor type	number in million	power per unit in hp	power in million hp
2 wheel power tiller . .	1·80	7	12·60
4 wheel light . . .	0·28	15	4·20
4 wheel medium . . .	0·12	34	4·20
4 wheel heavy . . .	0·08	65	5·20
total	2·28		26·20

It may be recalled that all tractor power is not utilized for farming operations. At present, the utilisation is estimated to be only 50 per cent as explained in Section 2. This position is likely to change by 2000 AD when more and more operations are performed with tractor power. Even then, tractors would continue to be used for extra-farm haulage and some allowance will have to be made for breakdowns etc. A 70 per cent of utilization is assumed for the future. The total effective power from the machinery indicated above will be only 18.34 million hp.

50.3.10 A noteworthy point about the estimates made in Appendix 50.4 is that the provision of medium and heavy tractors is so made that it would also suffice for difficult jobs like eradication of pernicious weeds, ploughing of sugarcane stubbles or black cotton soil areas. Another important feature of allocation is that power tiller (2 wheel walky type) has been provided in all parts of the country, mainly in the predominantly rice areas and to a small extent elsewhere too. The objects are twofold, viz., firstly it should be able to meet the needs of puddling operations in paddy crop wherever this crop is raised and secondly it should prove useful for other crops too for minor jobs like tillage in small vegetable plots, pumping of water of light nature and plan protection operations. Due to its lightness, the power tiller is considered suitable for hilly terrains, where the 4-wheelers cannot operate. Whatever modifications are needed in the design of the machine to make it versatile should be attended to. It is only then that the machine will become economic and people will be attracted towards it. The light 4 wheeler has also been provided everywhere with more or less equal emphasis so that it should be available for moderate operations in all situations-whether in respect of field crops or in gardens. This will be cheaper than heavier models and, therefore, will have more appeal with operators of larger holdings, say of 5 to 20 ha range.

Pumps for Irrigation

50.3.11 About half of the country's villages are proposed to be electrified by the end of the 5th Five Year Plan and in Chapter 19 on Electricity in Rural Development, we have emphasized that the remaining villages of the country should also be electrified by about 1990. When this happens, it would be possible to switch over to this source of power for as many stationary jobs as possible. Irrigation is one such sphere where reliance could be placed more and more on electricity. It has already been stated in Chapter 19 that the cumulative total of pumpsets at the end of the financial year 1978-79 will be about 4 million. It is also stated therein that there would still be

about 5.5 million wells which could be economically provided with pumpsets. Thus, the total number of pumpsets which would be needed in the country could be 9.5 million. In Appendix 50.1, it has been stated that the capacity of diesel engines and electric motors, which are used for agricultural purposes, usually ranges between 2.5 and 10 hp. With the progress of electrification, the choice will be more in favour of electric motors than diesel engines. Once electric motors become available in the required number, the dependence on diesel engines for irrigation would dwindle to a large extent. For this reason, it is assumed that the number of diesel engines in use in 2000 AD would be around 1 million only, which would contribute 7 million hp to the power requirement at an average rate of 7 hp per unit. Thus, the electric motors required for irrigation purposes would be 8.5 million. At present, electric motors are mostly owned by farmers on individual basis. However, we have advocated in Chapter 15 on Irrigation a community approach in this regard wherever possible, so that irrigation facility becomes available to many of the small farmers who cannot afford it otherwise. The capacity of electric motors suitable for wells to be operated on collective basis could be the same as indicated in Appendix 50.1, viz., 6.0 hp per machine, whereas the motor which has to be possessed on an individual basis could represent 4 hp on an average. The number of electric motors in the two ranges is assumed to be equal for the sake of calculation. In this manner, demand in terms of number and hp for pumps for irrigation purposes will be as follows:—

machine	average hp per machine	number of machines in million	total power million hp
electric motor	4	4·25	17·00
electric motor . . .	6	4·25	25·50
diesel engine	7	1·00	7·00
total		9·50	49·50

Electric Motors for Other Purposes

50.3.12 Electricity will have its utility for various other stationary indoor jobs. Farmers will like to operate their chaff cutters electrically. Small threshing jobs with respect to pulses and oilseeds can very easily be done electrically provided suitable machine becomes available. In big threshing yards for community use, where one can just go and get his produce threshed, use of electrical power will be ideal. To this can be added a long list of other operations like cane crushing, oil extraction, grain milling and needs of various cottage industries,

which would become popular in villages in course of time. For the time being, emphasis may be placed on the production of lower hp motors which can be put to use by farmers for many small jobs. Accordingly, the number of electric motors required for other purposes will be as follows :—

Number million	average hp per motor	total power million hp
3·0	2·5	7·50
0·5	6·0	3·00
		10·50

Plant Protection Equipment

50.3.13 Resort to effective plant protection measures will become inescapable in future for maximising production. Bigger land holders and orchard and plantation holders may even arrange for aerial operations from time to time. Even in normal course, they can build up facility for harnessing mobile power like tractor or stationary electric power for large scale plant protection operations according to situations. However, for an average farmer, the most favoured equipment will continue to be the back-mounted power sprayers and dusters, which consume but a little quantity of petrol as fuel. Presently, the attention will be confined to such equipment. It is not necessary for small holders to own this equipment ; it will be sufficient if the sprayers/dusters are readily available to them on custom service basis. Their number could be made to coincide with the number of operational holdings above 5 ha so that such owners could use the equipment themselves and also hire it out to others with smaller holdings. Thus, the number of this equipment would be 8 million for 2000 AD, which will contribute 16 million hp towards the total power.

Harvesting and Threshing Combines

50.3.14 As the name implies, these combines perform simultaneously the dual operations of harvesting and threshing ; these are particularly suited for wheat. There has been a demand for them in the wheat belt, because these machines reduce time and save the crop from the risk of thunderstorms and duststorms, the occurrence of which synchronizes with the harvest and threshing period of April-May. The number of combines at present available in the country is estimated at 500 units. Of these, nearly 200 combines are self-propelled, which are discussed in this chapter. However, the need for other combines which work with attachment to tractors cannot be over looked, these would be dealt with in the next chapter on Implements

and Tools. A single machine costs as much as Rs. 2 lakhs, which as a single factor is prohibitive enough to build a significant stock even for the organized agencies which might be ready to operate custom service; its possession by individual owners is unlikely. Further, the machine is not multi-purpose. As already stated, it is more suited for wheat, although it is claimed that the machine could be adapted for paddy, maize, jowar, bajra etc.

Power Position in 2000 AD

50.3.15 The number of men, draught animals, tractors, power tillers, engines and motors and power sprayers which should become available in 2000 AD. according to the foregoing discussion and their contributions in terms of horsepower are given in Table 50.1. The average power availability per hectare for the country as a whole works out to 0.86 hp. Electric motors and diesel engines, the bulk of which is for irrigation purposes would account for about 46 per cent of the total power requirements. Agricultural tractors would account for only 14 per cent whereas the share of draught animals would be 20 per cent. Plant protection equipment would account for 12 per cent in the power spectrum. An important point to be noted is that with the increase in heavy earth moving machinery and agricultural tractors and diesel engines, it would become very necessary to make available the required quantity of fuel oil. Agricultural needs for fuel would have to be given priority.

TABLE 50·1

Effective Power Position for Farming Operations as envisaged for 2000 AD*

Component	Number		Total power in million hp	Per cent of overall total	Total power availability in hp per 1000 ha
	million	per 1000 ha			
men . . .	140·00(a)	933	8·40	6·5	56·00
draught animals . .	64·00(a)	427	25·60	19·8	170·67
land development equipment (crawler tractor etc.)	0·017	..	1·28	1·0	8·53
agricultural tractor . .	1·60(b)	10·7	18·34	14·1	122·27
electric motor. . .	12·00	80	53·00	40·9	353·33
diesel engine . . .	1.00	6·7	7·00	5·4	46·67
power sprayer and duster .	8·00	53·3	16·00	12·3	106·67
over all position			129·62	100·00	864·14

*Total net sown area in 2000 AD would be 150 Mha.

(a) This is 80 per cent of the actual number; this percentage is reckoned to be engaged in actual farming operations.

(b) This is 70 per cent of the actual number; this percentage is reckoned to be engaged in actual farming operations.

50.3.16 We have to sound a note of caution that the estimates of average farm power requirements indicated in the preceding paragraphs should be used keeping in view that they are based on extremely empirical data at present available. The reliability of these estimates could, however be tested on the basis of the position obtaining in a country like Taiwan where small farms are the general order. In that country 60 per cent of the cultivated area is irrigated and grows paddy and the farm power available from different sources is about 0.3 per hectare. Since agricultural techniques in that country are highly scientific and productive it might be presumed that the farm power estimate is inclusive of the needs of tractorisation, irrigation, pest control and other modern practices. The fact that Taiwan has been able to sustain a highly productive agriculture with only 0.3 hp per hectare serves to indicate that our estimate of 0.86 hp is tentative and requires further study and analysis. We would, however, sound a serious note of warning that a rapid mechanisation on the basis of this estimate will be quite unwarranted. We may also add that major part of power from mechanical sources is required for irrigation, which is generally considered as land augmenting and employment generating. There should, however, be detailed research and analysis to find out the fair requirement of farm power in the various agro-climatic zones in the country under-irrigated and non-irrigated conditions. We also feel that the efficiency of human labour and draught animals on the farms can be considerably enhanced by improving the implements that are in use. In fact this aspect should receive first priority. The matter is discussed in the following chapter on Implements and Machinery. The Commission attaches utmost importance to the need for employment orientation in agricultural techniques. It is our considered view that any tendency to resort to use of machines in labour surplus areas in order to circumvent problems of labour management or which may result in lowering wages should be suitably controlled. Use of machines might be encouraged in areas where there is serious shortage of human labour and draught animals.

4 MANUFACTURE, QUALITY CONTROL, SUPPLY AND SERVICES

50.4.1 There was a time when farm machinery was mostly imported from outside the country. Then began the phase of manufacturing the required type of machinery in the country itself. In the case of tractors and power tillers there has been collaboration with foreign countries in order to avoid wasteful expenditure. The industrialists

will have to seek such arrangements for some more time before they could select the best technology suited to Indian conditions. This should not be grudged so long as the country concerned is willing to sell the technology on reasonable terms which the Government of India even now ensures. We view with satisfaction the country's capability to manufacture machines and recognise that it is because of this capability that in August, 1973 the Ministry of Heavy Industry could take a decision to ban the import of completely built tractors from outside.

Production Capacity

50.4.2 With regard to tractors, the licensed capacity with established firms is about 147,000 units per annum; besides letters of intent have been issued for another 41,000 units. Thus production of tractors in the country can be raised to 188,000 units per annum, if need be. We are quite convinced that a tractor with standard diesel engine, is well within the capability of Indian designers/manufacturers now. If all the factories issued with licences or letters of intent start producing even half the approved capacity, there should not be any difficulty in meeting the requirements of the country, which is estimated at 0.48 million in 2000 AD. It is, however, desirable that each of the different makes should have inter-changeability to maximum numbers of fast moving parts. As far as possible, such parts should be standardised to facilitate repairs and replacements. The Government should keep a constant watch to ensure that the increasing demand for tractors is met by the industry promptly and that the latter does not face any serious problem in regard to essential raw materials etc.

50.4.3 Regarding 2-wheel power tiller, there has been an attempt for total Indianisation of the Japanese model, but the design rights even then were required to be purchased from the source country. However, majority of the power tillers now under production are through collaboration with Japanese firms. There are six licenced units at present, situated at Kanpur. Ahmedabad, Shiroli (Kolhapur district), Hyderabad, Bangalore and Trivandrum with a total licenced capacity of 40,000 units per annum, but the internal production has not yet exceeded 350 units per annum. The present number in circulation is about 10,000 and what is planned for 2000 AD is 1.8 million. There is no doubt about its utility and we have already stated in Section 3 that the machine should be made versatile so that it could be employed for other operations besides puddling in the case of paddy as also for various operations in respect of other crops. We

have also stated that this machine is particularly suited to hilly terrains where heavy machines cannot work. As such, what require to be critically examined are : (a) how best to make the machine widely acceptable ; (b) bottlenecks in its manufacture, which impede production ; and (c) how best to eliminate those bottlenecks. A vigorous extension drive would be necessary to popularise the power tiller. On the production side, the steps needed are (a) to utilise fully the present capacity, (b) to expand production in the existing units themselves ; and (c) to examine whether the excess capacity in tractor manufacturing firms can be diverted to increase production of this machine in accordance with the rising demand.

50.4.4 Diesel engines and electric motors are now being manufactured in various sizes and horse power by a large number of manufacturers. The installed manufacturing capacities for diesel engines and electric motors suitable for agricultural purposes (usually between the range 3-10 hp) by the end of 1970-71 were about 1.55 lakhs and 6 lakhs respectively of which 4.25 lakhs were in public sector. These two sources of power are well within the capability of Indian industry. We observe that in recent years, the large scale sector has started exporting motors to a number of developing countries.

50.4.5 There are already about 35 to 40 small scale manufacturers, 6 to 8 medium scale manufacturers and 3 to 4 large scale manufacturers engaged in the manufacture of plant protection equipment. It will not be difficult to raise the production of this equipment particularly after the involvement of the state agro-industries corporations as indicated later in the section.

50.4.6 There are a few firms licensed to manufacture crawler tractors. Among them the Bharat Earth Movers which is a Government of India undertaking has started regular production through foreign collaboration. The installed capacity for crawler tractors was 600 and production only 233 in 1971. The firms which are already in the line, should be in a position to meet the future demand. What is really needed is to produce heavier machines of 150 hp than those of 50-90 hp range, which are being manufactured at present.

Testing and Quality Control

50.4.7 Most of the manufacturing licences are issued on the basis of recognised test reports. In India, facilities for testing the performance of various farm power machinery are limited. There are two Tractor Training and Testing Centres under the Ministry of Agriculture & Irrigation, one at Budni (Bhopal) and the other at Hissar. The centre at Budni was established as early as in 1955. The other centre

came into being in 1962. A third centre is being set up at Mysore in Karnataka. Besides, the Pantnagar and Ludhiana Agricultural Universities and the Indian Institute of Technology, Kharagpur also do testing of farm power machinery in a limited way, but these centres are not primarily equipped for commercial testing. As the emphasis is going to be on intensification of research and development to replace all foreign knowhow in future, the existing testing facilities at Budni and Hissar are required to be expanded and this aspect has to be kept in view in the case of the new centre as well. A testing station should also be attached to the Central Institute of Agricultural Engineering which has been set up recently. If the pressure of work so demands, the testing facilities at some selected agricultural universities will also have to be strengthened. As large scale farm power machinery industries have to depend upon ancillary industries for components, there is need to standardise the ancillary parts too so that unauthorised manufacturers may not be able to introduce spurious parts and replace the genuine ancillary components. The Indian Standards Institution has been standardising the implements and tools; they should make a beginning in standardising the main components of farm power machinery too.

Sale and Service

50.4.8 Sales of farm machinery are undertaken by authorised agents and sub-dealers in the case of large scale manufacturers and generally by manufacturers themselves in the case of medium and small scale industries. After the emergence of agro-industries corporations in different States they have assumed a major role both in production and distribution of farm machinery. It is recognised that the worth of a machinery depends on the service and repair facilities available to it. A good piece may fail to perform well if the after sale service is poor. A tractor model, like RS09, supposed to be a sophisticated one having excellence of performing inter-row cultivation, mass spraying of plant protection chemicals and other specialised operations, failed to impress the farmers of Punjab because of poor service facilities, although other factors like specialised operators' training and feature differences from general tractors might also have been partly responsible. Sudden rush for tractors, diesel engines, electric pumpsets etc. in the wake of green revolution has not been backed by proper service infrastructure. Most of the service and repair centres that sprang up did not possess necessary facilities for providing efficient service. A good number of men who handled the job were self-trained and

often charged heavily for their service. In some cases, even for such unsatisfactory services, farmers had to travel long distance. The Commission had circulated a questionnaire to elicit opinion of various industries manufacturers/dealers. From the replies, it is found that all major farm machinery manufacturers claim to ensure that their authorised dealers recruit skilled workers for after sales service. They also have the provision of training dealers' men at the factory training centres. These dealers are committed to give free services during the warranty period and afterwards on payment basis. They are also supposed to demonstrate to farmers the operation/general maintenance techniques as a part of sales promotion. However, these measures are rarely put into practice effectively.

50.4.9 Another serious handicap in the spread of power machinery among farmers is the cost factor. The experience already gained with tractors shows that hire-purchase scheme offers a satisfactory solution to the problem. Already several nationalised banks have stepped in for financing the purchases of farm power machinery and loans are given on short/medium/long term basis depending upon the type and cost of machines and the credit-worthiness of the purchasers. The hire-purchase of farm power machinery is relatively a new area for commercial banks. The conventional practice of assessing credit-worthiness of farmers is based upon the value of land holdings. A margin money of 25 per cent is charged and the banks require guarantors for sanctioning the loan application. Farmers specially find it difficult to find guarantors to effect their purchase. It is also reported that the nationalised banks consider loan applications of farmers operating within 16 kilometres of their operating radius. A study shows that the time taken for release of loan is sometimes between 164 days to 44 days and the money spent on securing loans is between Rs. 265/- to Rs. 893/- per application in Kolar and Ludhiana. In order to remove such difficulties, rural credit should be made more liberal and the hire-purchase system made more simple.

Agro-Industries in Supply and Services

50.4.10 Agro-industries corporations were set up under the Company's Act, 1956 as joint ventures of the Government of India and the State Governments, the two sharing finances in majority of the cases on a 50:50 basis. The principal objectives in setting up these corporations were two fold : (a) enabling persons engaged in agricultural and allied pursuits to own the means of modernising their operations and (b) distribution of agricultural machinery and imple-

ments as well as equipment pertaining to processing, dairy, poultry, fishery and other agro-industries. These corporations have been established in 17 major States between 1965 and 1970. The States of Meghalaya, Nagaland, Manipur, Tripura and the Union Territories, do not have such corporations at present. When the power machinery, particularly tractor, was imported, these items were distributed through the corporations. With the setting up of manufacturing factories within the country, the sales are to some extent directly performed by manufacturers through their distributors, but the corporations still undertake to arrange for the equitable distribution of certain selected makes relieving direct governmental involvement to a great extent. In the early stages, they advanced loans to farmers for purchasing agricultural machinery, implements and accessories. However, the latest trend is not for direct involvement in advancing loans. They now render advice and encourage farmers to secure loans directly from scheduled banks.

50.4.11 Several corporations, have themselves undertaken the manufacture of machinery, implements, accessories and spare parts for instance the Uttar Pradesh State Agro-Industrial Corporation Ltd., Lucknow, manufactures tractors, harrows, cultivators, discs, trailers etc. The corporation in Bihar has taken up the work of assembling Kubota power tillers and is expected to take up assembly of Zetor tractors in collaboration with Hindustan Machine Tools Ltd. The Kerala Agro-Machinery Corporation, a subsidiary of Kerala Agro-Industries Corporation, is also assembling Kubota power tillers. The Punjab Agro-Industries Corporation Ltd., Chandigarh, has established a factory for manufacturing and developing agricultural implements. Hindustan Tractors Ltd., Baroda has been transferred to the Gujarat Agro-Industries Corporation Ltd., Ahmedabad. Tractor drawn implements are being manufactured by the Rajasthan Agro-Industries Corporation Ltd., Jaipur. Corporations in the States of Haryana, Madhya Pradesh, Maharashtra and Tamil Nadu are also engaged in this activity. Corporations of the States of Assam, Haryana, Himachal Pradesh, Karnataka, Kerala, Punjab, Tamil Nadu, Rajasthan, Uttar Pradesh and West Bengal have established workshops for providing farmers facilities for repairs and maintenance of agricultural machinery and implements. Karnataka and Punjab Corporations have also made arrangements for mobile workshops which undertake repair and service machinery of the farmers. Most of the state agro-industries corporations provide custom service in regard to heavy machineries for land development and for boring of wells. Aerial spraying of crops is another activity which has been undertaken by the corporations of Gujarat, Madhya Pradesh and Andhra Pradesh ; it is being taken

up in Punjab and Haryana as well. Punjab Corporation is also providing custom service for harvesting wheat with combines.

50.4.12 Many of the State agro-industries corporations arrange for a brief pre-sale familiarisation training for farmers in operating and handling the machinery. A scheme was formulated during 1970-71 to train and assist unemployed engineers, diploma holders and agricultural graduates in establishing agro-service centres all over the country through the aegis of these corporations. So far, this activity has been undertaken in 13 States, viz., Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan and Uttar Pradesh. The corporations of Karnataka and Kerala States arrange special training for operators of tractors and other machinery. The former also arranges training of progressive farmers and its own employees so as to enable them to undertake the work of repair and servicing of agricultural machinery including pump sets.

50.4.13 The above mentioned activities pertaining to power machinery could be identified as common to almost all State agro-industries corporations. Besides there are many other activities undertaken by these corporations ; these, however, vary according to special circumstances obtainable in their respective States, which would be clear from the following account :—

(i) Andhra Pradesh, Bihar, Karnataka, Kerala, Maharashtra and Punjab State Corporations sell iron and steel for the manufacture of agricultural tools, implements, storage bins, curing bins, etc. The Himachal Pradesh Corporation arranges to distribute tree spray oil packing materials like nails, wood-wool, used newspapers, galvanised iron wire, etc., to horticulturists. The Punjab Corporation has set up diesel and petrol pumps for the supply of fuel lubricants to farmers. The Agro-Marine Products Ltd., a subsidiary of Gujarat Agro-Industries Corporation, supplies fuel to mechanised boats for fishing.

(ii) Activities relating to processing of seed and its supply to farmers have been undertaken by the corporations of Bihar, Karnataka, Maharashtra and West Bengal. Mixing of fertilizers and sale have been undertaken by the corporations of Haryana, Karnataka and Madhya Pradesh, while the corporations of Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal are only handling the sale of fertilisers. The corporations of Gujarat, Karnataka, Maharashtra and Tamil Nadu only arrange sale of insecticides/pesticides to farmers, whereas those of the States of Andhra Pradesh and Haryana have taken up their formulation as well. The Karnataka Agro-

Industries Corporation has set up super-bazar type of complex where farmers can get all farm inputs under one roof. Corporations in several States like Bihar, Haryana, Karnataka, Maharashtra, Orissa and Uttar Pradesh manufacture balanced cattle and poultry feed.

(iii) Corporations of Andhra Pradesh, Assam, Gujarat, Haryana, Karnataka, Maharashtra and Uttar Pradesh have established fruit processing units for the manufacture of fruit products for sale in the country as well as for export. Haryana Corporation has undertaken the manufacture of malt and also flour milling. Undertaking of freeze-drying of mango and prawns, manufacture of edible grade gram flour and protein concentrate, processing of maize and castor beans is all being considered by the Andhra Pradesh Corporation. Similarly, the Karnataka Corporation has under consideration plans for the manufacture of chilli extract, liquor and *feni*, tamarind seed meal, cotton-seed and groundnut protein concentrate, rice bran products, tomato seed oil, starch, gluten and dextrin from maize, grape juice and lucerne extract. The Gujarat Corporation has set up a number of subsidiary corporations such as Agro-Oil Enterprises Ltd., which manufacture groundnut oil and rice bran oil and Agro-Marine Products Ltd., which operates fishing trawlers and hires out boats to fishermen on the condition that they will provide the Corporation with the catch for processing. There are even proposals to go in for the culture of pearls and edible oysters.

(iv) Cold storages have been set up by the corporations of Bihar, Gujarat, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh and Uttar Pradesh mainly to provide facilities to the growers for storing fruits and potato.

(v) The Gujarat Agro-Industries Corporation is establishing a mechanical compost manure plant with a capacity (input) of 100 to 150 tonnes per day. The Karnataka State Agro-Industries Corporation has engaged itself in the setting up of gobar gas plants.

(vi) Some miscellaneous activities undertaken by them in their respective States are cotton ginning in Haryana and Karnataka ; manufacture of packing cases, menthol, pine oil, collection and sale of honey, marketing of spices in Uttar Pradesh ; purchase and sale of wheat bran in Maharashtra ; compost manure manufactured from city garbage in Gujarat ; food processing, ground water development, survey of areas for launching development schemes and establishment of testing laboratory for endurance test of oil engines in Andhra

Pradesh ; and renovation of dry wells and establishment of mechanised farms in Madhya Pradesh. The Himachal Pradesh Agro-Industries Corporation even handles the forwarding and warehousing of apples with a view to ensure quick and better transportation of fruits from the growing areas to various markets in the country and safe storage of the produce while in transit.

Future Role of Agro-Industries Corporations

50.4.14 From a cross section of their activities, which have been described in the previous paragraphs, it emerges that these corporations have been undertaking activities pertaining to the supply of inputs including the farm machinery on the one hand entering on the other in such ventures in which it could have been ordinarily difficult to find other entrepreneurs. The latter set of activities are indeed very desirable, because these ensure the offtake and proper utilisation of the farmers' produce. Their role in marketing of seed has already been mentioned in Chapter 47. What role should these corporations play in various industries including mixing of fertilisers and plant protection chemicals and processing of agricultural produce is dealt with separately in Chapter 57 on Processing and Agro-Industries. Attention is being confined here to their role in regard to farm machinery. They are already doing a good job in this respect, but a lot more is waiting to be accomplished in future. This will be discussed below under three separate heads of manufacture, supply and services.

(i) Manufacture: With regard to farm power machinery, their role is only to ensure that the manufacture of ancillaries, accessories and spare parts keeps pace with demand. Their primary role has to be to render or arrange for all possible help to small and medium scale manufacturers. Their direct role of manufacturing should be confined to only such items, the manufacture of which cannot be undertaken by other parties or where the manufacture by other parties is required to be supplemented by extra production.

(ii) Supply : The responsibility of equitable distribution of machinery must continue to vest in these corporations. They have to ensure that the needy get the equipment speedily and without inconvenience. The alternative of people getting their requirements directly through manufacurers should always be available, but a major role must be played by the corporations both from the viewpoint of proper distribution and keeping the prices within reasonable limits. Financial aid should come from the banks and other appropriate

institutions. Small and medium manufacturers have often felt the difficulty of selling their goods, especially in off season. In order to remove this kind of difficulty, the corporations should make necessary arrangements for their stocking and sale.

(iii) Services : The agro-industries corporations should continue to provide essential training to purchasers. Two kinds of services are being visualised for these corporations, viz., (a) custom-service and (b) workshop facility. To be effective to serve farmers in every nook and corner of a State, it is necessary that every taluka should have a full-fledged workshop, properly equipped and capable of undertaking all kinds of repairs and providing custom service. Each taluk workshop should have its forward operating posts in the assembling and sub markets which have been suggested in Chapter 56 on Marketing, Transport and Storage. These forward posts should have some essential repairing and custom service facilities to be able to serve the farmers more or less at their door. The number of such workshops for the country as a whole would be in the neighbourhood of 30,000. Their establishment should constitute an important responsibility of the agro-industries corporations. They could encourage private entrepreneurs for this purpose wherever possible, but they should be ready to fill in the gaps by direct involvement elsewhere, more specially in the inaccessible areas.

(iv) The agro-industries corporations should also take initiative in organising community threshing and other kinds of post-harvest processing centres in villages, which facility can then be utilised by individual farmers on payment. The corporations need not involve themselves directly in this task. The village panchayats could undertake this activity and charge fee for the service rendered. It would provide them some income with which they can finance other activities for the welfare of villages.

50.4.15 It was mentioned earlier that Meghalaya, Nagaland, Manipur, Tripura, and the Union Territories do not have agro-industries corporations. The Ministry of Agriculture and Irrigation had once considered the question of establishing such a corporation for Delhi area. It was then felt that a corporation in such a small area would not be viable. The same observation would hold good for some of the States and administrations mentioned above. At the same time, there is surely a need to extend such activities as are being undertaken by the agro-industries corporations in other States on a

common pattern to these areas also. We have given thought to this problem and have come to the conclusion that the agro-industries corporations of neighbouring States should be made responsible to cover their respective smaller neighbouring States and Union Territories.

5 ORGANISATION, EDUCATION AND RESEARCH

Man Power Requirements

50.5.1 It is necessary now to have an idea of the magnitude of the tasks relating to manufacture, supply and management of power machinery in terms of the needed manpower. The tractors and heavy earth moving machinery like crawlers need more number of skilled hands per unit whereas power tillers and diesel engine/electric motor operated machines require less. The tractor-man employment ratio from manufacturing to usage has been generally accepted as 1 : 5. Corresponding ratios for 2-wheeled power tillers, diesel engines/electric motors, power sprayers/dusters have been assumed as 1:2, 5:1 and 8:1 respectively keeping in view the tractor ratio. On this basis, the manpower requirements for the targeted machinery would be about 10 million as indicated in the following table :—

Machine type	Number of machines (million)	Machine man ratio	Total manpower needed in million
land development equipment and agricultural tractors excluding 2-wheel power tiller	0·50	1:5	2·50
power tiller	1·8	1:2	3·60
engine/motor	13·0	5:1	2·60
sprayer etc.	8·0	8:1	1·00
total			9·70

This number would include agricultural engineers, diploma holders, technicians and skilled personnel. In addition, a vast number of farmers will have to acquire competence to operate the power machinery and undertake on-the-spot maintenance jobs.

Education and Training

50.5.2 The agricultural universities and the Indian Institute of Technology, Kharagpur have arrangements for turning out agricultural engineering graduates and post-graduates. Except for one Agricultural Engineering Institute at Raichur under the University of Agricultural Sciences, Bangalore, there are no arrangements at present for making available the middle level technical personnel with diploma qualification in agricultural engineering. In so far as lower level training is concerned, there are 4 or 5 private tractor manufacturing organisations imparting training to the staff of appointed dealers. It is mainly meant for mechanics and supervisors, who are ultimately responsible for maintenance and repairing services. The G. B. Pant Agricultural University and the Indian Institute of Technology, Kharagpur provide practical training in the operation and maintenance of tractors and other power machineries, but this is mainly for undergraduate students. The Tractor Training and Testing Centres under the Ministry of Agriculture and Irrigation impart training to farmers in improved farm power machinery. The number of trainees admitted annually at present is around 500 and these mostly come out as trained operators. Besides, there are about 44 *gramsevak* training centres in various States attached with a workshop wing to impart training to *gramsevaks* and artisans. But very few of them provide training in farm power machinery as they are basically meant for shop floor training in manufacture of small agricultural implements and tools.

50.5.3 The information furnished by the agro-industries corporations indicates that most of them have made arrangements, under which farmers or their nominees are given necessary instructions in the operation and maintenance at the time of delivery of machines. There does not seem to exist any fixed standard of regular pre-sale training in the use and maintenance of agricultural machinery. In Punjab, the corporation organises training camps for farmers before delivery of tractors in which specialists of foreign suppliers and experts from other specialised agencies are associated and training is provided to farmers on a systematic and scientific basis. At Ludhiana it proposes to start a training centre to train unemployed engineers and other technical personnel with a view to assisting them in setting up the agro-service centres. It is proposed to utilise these centres for providing training to farmers in the maintenance and use of tractors. In Karnataka, apart from making the farmers know the salient features of the machinery at the time of delivery, service personnel of the corporation are being deputed for a period of 3 days to guide individual farmers on the farm, in the operation, hitching of

implements and the proper use of machinery and implements supplied. The corporation has a separate division with a Research, Testing and Training Centre which undertakes the training of farmers in the use of machinery and implements distributed by the corporation. Training courses are conducted at regular intervals depending on the number of machinery distributed and the need for such training. In Andhra Pradesh, at the time of delivery of tractors, a demonstration of their operations and maintenance is carried out and advice on the utilisation of matching implements is given. During the demonstration, stress is laid on the operation of various tractor controls including the operation and judicious manipulation of tractor implements during transport and in the course of agricultural operations. Apart from this short training at the time of delivery, operation manuals dealing with the operation and day-to-day maintenance are also supplied to farmers.

50.5.4 The kinds of arrangements, which have been described above, are not going to be sufficient to train about 16 million people in various categories of jobs. The manufacturing and workshop facilities, which are being contemplated on a very liberal scale, would certainly necessitate diploma and certificate courses in agricultural engineering. The farmers' operational training has also to be put on a common footing throughout the country. So far, the number of farmers needing training has been limited and, therefore, the agro-industries corporations could cope up with the job. This will not be so in future when a vast number of farmers will take to farm power machinery. Just for getting an idea of the number of farmers, who would need training in handling the machinery, one may relate them with the number of power tillers and agricultural tractors. Assuming that even half the number of such machines will be operated by individuals and the other half through custom service, the number of farmers requiring training will be about 1.14 million. Electric motors, diesel engines and plant protection equipment also requires skill in operation. Their number is 21 million. If even 10 million farmers are expected to get some familiarisation training in their working and upkeep, the total number of farmers needing training will run into about 11 million. If agro-industries corporations are required to undertake a job of such a colossal magnitude it is certain that they will not be able to pay adequate attention to their main activities For this reason it is very necessary that the agro-industries corporations should not be made responsible for the training of farmers. The States could have separate arrangements for diploma in agricultural engineering education in their engineering polytechnics and certificate training of agricultural technicians in the industrial training institutes. The familarisation training of farmers in the holding of power machinery should

be organised by State Departments of Agriculture themselves ; they may seek the cooperation of the agro-industries corporations by utilising their facilities but the corporations should not be burdened with any responsibility in this regard.

50.5.5 With greater involvement of power machinery in farming operations, envisaged in this chapter, it is likely to assume the role of an important input in crop production. With this is linked the problem of creating receptivity for such machinery among farmers. In this respect, it has already been pointed out that the extension support is almost non-existent at present. This is not the job which only the manufacturers can do on the scale in which it will be required to be done to be sufficiently effective. This is once again not a job which could be entrusted to agro-industries corporations, because it would distract their attention from the main activities of supply, customs service and providing workshop facilities. In order to do full justice to extension work up to the village level, it is desirable that there should be a suitable cadre of graduate engineers and diploma holders in agricultural engineering available at the district, taluk and block headquarters. The agricultural engineering wings of the State Departments of Agriculture require to be strengthened to that extent.

50.5.6 There is a Machinery Division under the charge of an Additional Secretary in the Ministry of Agriculture and Irrigation at the Centre. The Government of India constituted a Board of Agricultural Machinery and Implements in 1969 with the Ministry of State in the Ministry of Agriculture and Irrigation as its Chairman and Secretary to the Government of India, Ministry of Agriculture and Irrigation (Department of Agriculture) as Vice Chairman. The Members of this Board include some Members of Parliament : senior officials of the Ministry of Agriculture and Irrigation dealing with the subject and similar officials of sister departments like Economic Affairs and Industrial Development Secretary. National Cooperative Development Corporation senior officers of State Agricultural Departments representing the subject of agricultural engineering ; Managing Directors of state agro-industries corporations ; manufacturers ; Managing Director Central State Farms Corporation and a representative of the ICAR. The functions of the Board consist of the following:—

(i) to review programmes of manufacture, servicing and maintenance of power tillers, tractors, agricultural implements etc.;

(ii) to review from time to time availability and distribution and arrangements of the above items ;

(iii) to review the credit requirements for as also popularisation of the above equipment ; and

(iv) any other matter concerning the industry engaged in the manufacture and distribution of the above machinery and implements.

The Board is reconstituted periodically at an interval of about 3 years. The setup at the Centre is considered adequate.

Research

50.5.7 The success of future mechanisation depends largely on developing an appropriate technology that can fit in well between the traditional and modern technology. The existing farm power machinery being mostly of foreign origin is not considered at the right answer. Besides high cost, it is either big in size or has sophistication in design or has complexities of basic raw material mix. The Central Mechanical Engineering Research Institute, Durgapur (West Bengal) has taken some initiative due to which it has been possible to develop a tractor named 'Swaraj', which is now under production in Punjab. Such a step should be considered only a beginning towards the development of farm power machinery suited to the country's conditions. What is needed is the embarking upon a well considered plan to screen all kinds of machinery through research work and develop the most suited ones.

50.5.8 Generally speaking, there is no regular policy followed at present by the industry on research and development. No fixed funds for this purpose appear to be earmarked by any large scale industry. It should be the responsibility of the licensing authority to ensure that the industry spends on its own research and development programmes to the desirable extent. All manufacturing concerns should concentrate on producing such machinery which will suit most the conditions obtaining in different agroclimatic regions. In order to isolate specific problems a get-together between agronomy and agricultural engineering experts is very necessary. This work can be attended by the Central Institute of Agricultural Engineering, which has already been set up. This institute should not only conduct its own programme of research but should also be able to provide a forum for exchange of ideas between agricultural scientists and engineers and coordinate the research activities of manufacturers and other institutions.

50.5.9 There is much speculation about the power needs for maximising production. We have already observed in section 3 that it is necessary to undertake detailed research and analysis to determine the power requirements of typical regions under irrigated as well as unirrigated conditions. The ICAR has sponsored a research programme about two years back for conducting experiments to determine the energy requirements for production of various crops. Quite

a number of institutes and universities representing different regional conditions are involved in it. The Central Institute of Agricultural Engineering should coordinate all this research work and take a lead in undertaking studies on various facets of mechanisation, e.g., the optimum levels of mechanisation under different conditions, the operations to be mechanised, the ideal machines to be used for different operations, the usefulness of timely operations through mechanisation during critical periods of growth, the problems of management of mechanised farms, level of capitalization of holdings through investment on machines, labour input per unit area—whether hired, casual or permanent in the suggested research programme. For this purpose, the Central State farms could prove very useful. These farms are large and situated in different parts of the country representing different agroclimatic conditions. Most of farm operations are mechanised. These farms could be utilised by the Central Institute of Agricultural Engineering.

6 SUMMARY OF RECOMMENDATIONS

50.6.1 The aggregate farm power available at the turn of the century will be of the order of 129.62 million hp, which gives an average power availability of 0.86 hp/ha. Of this the share of human labour would be 8.40 million hp, draught animals 25.60 million hp, tractors including crawlers and power tillers 19.62 million hp, engines and motors 60.00 million hp and power sprayers and dusters 16.00 million hp. The various recommendations given in the chapter are directed towards achieving this goal. The main recommendations are the following :

1. There should be provision for extending loans covering the full cost of draught animals. Advances should be made available in time and if there are any bottlenecks Government should so frame the rules that it becomes easy for farmers to get the advances. Credit cooperatives and commercial banks should also undertake advancing such loans.

(Paragraph 50.3.3)

2. The two-wheeled power tiller which is mainly used at present for puddling operations in paddy fields should also be designed for other light jobs like tillage of minor nature, water pumping, and spraying and dusting operations. It should be particularly popularised in hilly regions where other heavy machinery cannot be worked.

(Paragraph 50.3.10)

3. The use of electricity should be popularised as much as practicable in farm activities and stationary indoor jobs.

(Paragraphs 50.3.11 and 50.3.12)

4. It should be ensured that fuel oil required for farm machinery like tractors and earth moving machinery is arranged on a priority basis.

(Paragraph 50.3.15)

5. There should be detailed research and analysis to find out the fair requirements of farm power in various agroclimatic zones in the country under irrigated as well as unirrigated conditions.

(Paragraph 50.3.16)

6. Machines should be utilised only in areas where there is serious shortage of human labour and draught animals. Any tendency to utilise machines in labour surplus areas should be suitably controlled.

(Paragraph 50.3.16)

7. In the manufacture of tractors, it is desirable to ensure that interchange of the fast moving parts becomes possible between different makes in order to facilitate repairs and replacement. The Government should keep a constant watch on production so that farmers' needs can always be met in full and the industry does not face any difficulty in regard to essential raw materials etc.

(Paragraph 50.4.2)

8. Particular attention should be given to popularise the two-wheeled power tiller and to manufacture them in accordance with the rising demand as explained in the text.

(Paragraph 50.4.3)

9. Crawler tractors of 150 hp capacity are required to be manufactured specially for heavy earth moving work.

(Paragraph 50.4.6)

10. Facilities of testing power machinery should be expanded at the Tractor Training & Testing Centres. A testing section should also exist at the Central Institute of Agricultural Engineering, which has been set up recently. Facilities for testing of commercial equipment should also be created at some agricultural universities depending upon need. The Indian Standards Institution should start laying down specifications for ancillary parts of farm power machinery.

(Paragraph 50.4.7)

11. Procedure followed by banks should be simplified and rural credit made more liberal than at present in order to make it easy for farmers to purchase agricultural machinery.

(Paragraph 50.4.9)

12. The agro-industries corporations should undertake manufactured only of such items which are not being manufactured by others or the production of which is not sufficient and, therefore, requires to be supplemented.

(Paragraph 50.4.14(i))

13. The agro-industries corporations should assist small and medium scale manufacturers by purchasing their stocks and taking over the responsibility of their sale upon themselves.

(Paragraph 50.4.14(ii))

14. The agro-industries corporations should offer two kinds of services, viz., (a) custom-service and (b) workshop facility for overhaul and repairs etc. In order to be able to perform both these functions, full-fledged workshops should be established at each taluk headquarters and there should be arrangement for some essential facilities to be made available at a sufficiently dense network of points below the taluk level also. Wherever other entrepreneurs are coming forward, they should be encouraged to open workshops. In other places, particularly inaccessible areas, the corporations themselves should take up this responsibility.

(Paragraph 50.4.14(iii))

15. The agro-industries corporations should encourage creation of community threshing and post-harvesting processing facilities in villages. Panchayats could profitably undertake this activity.

(Paragraph 50.4.14(iv))

16. The agro-industries corporations of major States should extend their activities to their neighbouring smaller States (i.e. Meghalaya, Nagaland, Manipur and Tripura), and Union Territories.

(Paragraph 50.4.15)

17. The agro-industries corporation should not remain responsible for the training of farmers with regard to handling of farm machinery. The extension work with regard to such machinery should also not be considered as a function of these corporations.

(Paragraphs 50.5.4, 50.5.5)

18. A course in agricultural engineering should be introduced in engineering polytechnics as well as in industrial training institutes.

(Paragraph 50.5.4)

19. Training of farmers in the handling of farm power machinery should be performed by the State Agricultural Departments.

(Paragraph 50.5.4)

20. The State Departments of Agriculture should organise extension work relating to farm power machinery in an effective manner.

For this, they have to provide duly qualified staff at the district, taluk and block headquarters.

(Paragraph 50.5.5)

21. A research base for producing power machinery suited to Indian conditions is very necessary. The present machinery in use has to be tested with this aim in view and suitable modified types developed. The manufacturers must create their own research and development units. It should be the responsibility of the licensing authority to ensure that they allocate adequate funds for this purpose.

(Paragraphs 50.5.7 to 50.5.8)

22. Besides conducting its own research, the Central Institute of Agricultural Engineering should bring together agricultural scientists and engineers in order to determine problems and priorities. It should also try to coordinate the research activities of the manufacturers and other institutions.

(Paragraph 50.5.8)

23. With the help of the central state farms, the Central Institute of Agricultural Engineering should undertake studies to determine the optimum levels of mechanisation under different conditions of soil, climate and irrigation and to collect information on related apsects.

(Paragraph 50.5.9)

APPENDIX 50·1

(paragraph 50·2·3)

Work capacity of Man, Draught Animal and Machines in Terms of Horsepower

1. Only a few agricultural colleges like Agricultural Institute, Naini (Allahabad) are known to have conducted experiments to determine the capacity of human participants and draught animals in terms of horsepower for undertaking various agricultural operations. However, documented records are not easily available. Certain equivalents for men, animals and machines have been given by Roy[1]. Certain norms were indicated by Donde[2] and Pathak[3] in their contributions, which were invited by the Commission. These are given in the Statement I of this Appendix.

2. Human component is sometimes taken as equivalent to 0·1 hp without distinction of sex. We are inclined to maintain a distinction between a male and female worker. We also feel that a contribution of 0·10 hp may not be tenable for long hours due to fatigue that sets in after some initial period. Consequently, we have accepted the value of 0·07 hp for male and 0·05 hp for female just for calculation purposes. For bullocks and he-buffaloes, we have accepted 0·4 hp per animal and on this basis we have assumed a value of 1·00 ph for a camel in areas like Rajasthan.

3. In so far as machines are concerned, different makes have different capacities. For example, lighter tractors, which were imported in the beginning, had a capacity of about 15 hp only. Tractors acquired about a decade ago ranged between 15 and 25 hp in certain areas; the present trend is in favour of tractors of 35 hp. Tractors of 50 hp and above are not that common. Therefore, for a general purpose like assessment of power availability for the country as a whole, the power equivalent for a tractor has been assumed as 25 hp.

There is no difficulty in assuming an average value of 7·0 hp for a Japanese type of power tiller. Keeping a comparative view, we have assumed that the average capacity of a plant protection equipment is 2·0 hp. The capacity of diesel engines and electric motors which are used for agricultural purposes, usually ranges between 2·5 and 10 hp. We have adopted an average value of 7·0 hp for diesel engine an 6·0 hp for an electic motor, keeping the diesel engine slightly on the higher side in conformity with the prevailing trend. We have also provided for motors use for operating cane crushers, threshers etc. It is assumed that these motors, on an average, will be of 6·0 hp capacity.

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1. Roy S.E., 1970, Agricultural Engineering in Agricultural Year Book : 481 ICAR, Ministry of Agriculture, Government of India.
2. W.B. Donde, 1972, Impact of Mechanisation on Employment, Paper submitted to the National Commission on Agriculture.
3. B.S. Pathak, 1972, Energy Requirements in Agriculture—A Draft Report: Paper submitted to the National Commission on Agriculture.

APPENDIX 50.1—(Concld.)

Horsepower Equivalents of Various Power Components as collected from Certain Sources

Component of Power	Power equivalent in hp		
	Donde	Roy	Pathak
human :			
male	0·10(a)	0·10	0·07
female		0·05	0·05
draught animal :			
bullock/he-buffalo	0·30	0·40	0·40
mechanical & electrical :			
tractor	30·00	25·00	25·00
power tiller			7·00
diesel engine	5·00	5·00(b)	7·00
electric motor	3·00(c)	3·00(c)	6·00
miscellaneous machines like power crushers and threshers		5·00	

(a) refers to agricultural labour without mention of sex.
(b) refers to irrigation, flour mills etc.
(c) refers to electrical pumps.

APPENDIX 50·2

(paragraph 50·2·4)

Existing Power Availability

STATEMENT I—Power for Agricultural Operation Available in 1971

Source	Number million	Hp equivalent per unit	Total hp (millions)	Hp/ha (c)	per cent of total
human(a) :					
male	69·7	0·07	4·9	0·0350	9·8
female . . .	17·7	0·05	0·9	0·0064	1·8
draught animals(a) . .	63·3	0·40	25·3	0·1807	50·8
tractors(a) . . .	0·07	25·00	1·8	0·0129	3·6
power tillers(b) . .	0·02	7·00	0·1	0·0007	0·2
power sprayers and power dusters . . .	0·24	2·00	0·5	0.0036	1·0
diesel engines . . .	1·25	7·00	8·8	0·0629	17·7
electric motors . .	1·16	6·00	6·9	0·0493	13·9
electrically operated sugar-cane crushers . .	0·10	6·00	0·6	0·0043	1·2
total all-India .			49·8	0·3557	100·0

NOTES :

(a) Only 80 percent of the economically active human work force and draught animals and 50 percent of the tractor population have been considered.

(b) This is 1972 Livestock Census estimate, which is higher than the Planning Commission estimate referred to in the text.

(c) Horsepower per hectare is estimated on the basis of average net sown area during the years 1968-69 to 1970-71 which was 140 M ha.

Compiled from: Census of India—1971, series I-India, paper 3 of 1972; Livestock Census—1972; and Data obtained from the States.

APPENDIX 50·2—(Contd.)

(paragraph 50·2·4)

STATEMENT II—Number of Districts (Statewise) in Different Ranges of Horse-power Representing the Total Animate (Human and Draught Animals) and Inanimate Power Available for Crop Production.

State	0·19 and less	0·20 to 0·39	0·40 to 0·59	0·60 to 0·79	0·80 and above	Total
Jammu & Kashmir . .	..	6	4	..	..	10
Himachal Pradesh . .	1	2	1	5	1	10
Punjab	..	..	1	1	9	11
Haryana	..	3	2	1	1	7
Rajasthan	11	10	3	2	..	26
Uttar Pradesh . . .	1	4	37	5	1	48
Madhya Pradesh . .	10	33	..	..	..	43
Bihar	..	2	12	3	..	17
West Bengal . . .	1	11	3	..	..	15
Assam	1	..	7	..	..	8
Orissa	..	11	1	1	..	13
Gujarat	1	9	6	2	1	19
Maharashtra . . .	7	15	4	..	..	26
Karnataka	4	8	4	1	2	19
Andhra Pradesh . . .	1	5	13	..	2	21
Tamil Nadu . . .	1	3	4	2	3	13
Kerala	3	5	3	..	..	11
Total districts . .	42	127	105	23	20	317

APPENDIX 50·2 (Concld.)

(paragraph 50·2·4)

STATEMENT III—Number of Districts (Statewise) in Different Ranges Horse-power Representing the Inanimate Power (Electrical and Mechanical) available for Crop Production.

State	0·19 and less	0·20 to 0·39	0·40 to 0·59	0·60 to 0·79	0·80 and above	Total
Jammu & Kashmir . .	10	..	..	..	..	10
Himachal Pradesh . .	10	..	..	..	..	10
Punjab	..	1	1	2	7	11
Haryana	3	2	1	1	..	7
Rajasthan	26	..	..	..	..	26
Uttar Pradesh . . .	32	14	2	..	..	48
Madhya Pradesh . .	43	..	..	..	..	43
Bihar	16	1	..	..	..	17
West Bengal . . .	15	..	..	..	..	15
Assam	8	..	..	..	..	8
Orissa	13	..	..	..	..	13
Gujarat	10	4	3	1	1	19
Maharashtra . . .	23	3	..	..	..	26
Karnataka . . .	14	2	1	2	..	19
Andhra Pradesh . . .	13	6	1	1	..	21
Tamil Nadu . . .	6	3	4	..	..	13
Kerala	9	2	..	..	..	11
Total districts . .	251	38	13	7	8	317

APPENDIX 50·3

(paragraph 50·3·1)

Power Needs

STATEMENT I—Monthly Power Needs for Crop Production in Hisar and Karnal Districts of Haryana (if these are to be met fully from Biological Sources)

unit=hp/ha/day

Month	Hissar Human	Hissar Animal	Hissar Total	Karnal Human	Karnal Animal	Karnal Total
January	0·01	0·04	0·05	0·01	0·00	0·01
February	0·01	0·00	0·01	0·01	0·00	0·01
March	0.04	0.01	0.05	0.01	0.01	0.02
April	0·04	0·07	0.11	0·05	0·09	0·14
May	0·02	0·03	0·05	0·01	0·03	0·04
June	0·01	0·02	0·03	0·02	0·04	0·06
July	0.02	0.05	0.07	0.03	0.08	0.11
August	0.04	0.01	0.05	0.03	0.01	0.04
September	0·02	0·02	0·04	0·03	0·01	0·04
October	0·05	0·10	0·15	0·07	0·12	0·19
November	0.02	0.03	0.05	0.02	0.06	0.08
December	0·04	0·00	0·04	0·04	0·00	0·04
available human and animal power	0·016	0·11	0·126	0·02	0·14	0·16

APPENDIX 50·3—(Contd.)

(paragraph 50·3·1)·

STATEMENT II—Monthly Power Needs for Crop Production in Bijapur and Kolar Districts of Karnataka (if these are to be met fully from Biological Sources)

unit=hp/ha/day

Month	Bijapur			Kolar		
	Human	Animal	Total	Human	Animal	Total
January	0·02	0·03	0·05	0·03	0·05	0·08
February	0·03	0·02	0·05	0.03	0·04	0·07
March	0·01	0·01	0·02	0·02	0·02	0.04
April	0·00	0·00	0·00	0·02	0·01	0·03
May	0.01	0·06	0·07	0·03	0·11	0·14
June	0·01	0·08	0·09	0·05	0·15	0·20
July	0·02	0·06	0·08	0·05	0·07	0·12
August	0·03	0·05	0·08	0·06	0·05	0·11
September	0·02	0·03	0·05	0·05	0·01	0·06
October	0·04	0·02	0·06	0·04	0·02	0·06
November	0·03	0·03	0·06	0·05	0·05	0·10
December	0·02	0·01	0·03	0·04	0·05	0·09
available human and draught animal power . .	0.01	0.05	0.06	0.07	0.24	0.31

APPENDIX 50·3 (Contd.)

(paragraph 50·3·1)

STATEMENT III—Monthly Power Needs for Crop Production in Burdwan District of West Bengal (if these are to be met fully from Biological Sources)

unit=hp/ha/day

Month	Human	Animal	Total
January	0·04	0·07	0·11
February	0·02	0·01	0·03
March	0·02	0·01	0·03
April	0·02	0·02	0·04
May	0·02	0·04	0·06
June	0·03	0·19	0·22
July	0·07	0·21	0·28
August	0·06	0.10	0.16
September	0·04	0.00	0·04
October	0·03	0·04	0·07
November	0·06	0·10	0·16
December	0·06	0·08	0·14
Available human and draught animal power	0·05	0·22	0·27

APPENDIX 50·4

(Paragraphs 50·3·9 and 50·3·10)

Requirements of Agricultural Tractors for Crop Production 2000 AD

1. For examining power needs for crop production, it is necessary to confine consideration to some concise and yet tangible form rather than go into all crops individually. Power tiller is considered an ideal machine for paddy cultivation. It could be a two-wheeled walky tractor as is commonly understood, but it could also be the light four-wheeled tractor often called garden tractor. Both kinds with suitable adjustments are capable of performing many jobs other than puddling The four-wheeled power tiller (garden tractor) can be used for tillage and inter-culture operations, for operating plant protection equipment, for harvesting in association with reapers and for light threshing operations. Even the two-wheeled power tiller can be used for light tillage operations, specially in small vegetable and floriculture plots, for light pumping of water and for plant protection operations. This would show that, power tillers could also be used for crops other than paddy grown in the same areas. A little augmentation of power with heavier tractors should be able to satisfy the needs of these areas. Thus, there should be no harm in considering the needs of all crops of peddy areas in onelot. The peculiarities of other crops will, of course, be given due consideration separately.

2. The entire Indo-gangetic basin forms one contiguous belt. The most common crop of this area is wheat. Hence it can rightly be called the wheat belt. Irrigation facilities are maximum in this belt. Intensity of cropping is also high because of which there is comparatively greater dependence on tractor power despite greater availability of animal power. This belt can take in all kinds of tractors for various kinds of jobs. Next to wheat belt, another contiguous belt could be identified for millet group of crops (jowar, bajra, ragi and small millets). This belt covers mainly Rajasthan, West Madhya Pradesh, Gujarat, Maharashtra and Karnataka. Two peculiarities have to be specially noted from the viewpoint of power needs. This belt includes areas which are arid or semi-arid, where sowing operations are required to be undertaken and completed at short notice according to the arrival of rains. Such a situation demands quicker means of doing jobs in vast stretches of areas in shortest possible time, which is possible only through the involvement of machine power. Secondly, this belt also includes areas with black cotton soil, which particularly require tractors if deep tillage operations are to be done effectively. Thus, the division of the country into wheat belt, millet belt and rice areas provides a suitable frame which can be extended to cover other areas as well. This is attempted as follows :

(i) The areas under barley and oat may be added to wheat area.

(ii) The water requirement of maize is high. Irrigation facilities are better developed in wheat and paddy tracts, and the alternative rain fall conditions are better in them. Owing to these reasons, maize area even now will be found to be situated in wheat belt and rice areas* to a large extent. Therefore, this area may be apportioned equally between the two.

(iii) The area under pulses, oilseeds and fodder is distributed throughout the country. Hence, this may be distributed among the three basic areas of wheat, rice and millets according to their proportions.

(iv) Cotton area of the States of Punjab, Haryana, Rajasthan and Uttar Pradesh could be added to wheat belt and that of the remaining States could be divided between the millet and rice areas in the proportion 3:1.

* Rice areas are not as contiguous as those of wheat or millets from all-India point of view. Hence, the usage of the ter 'bel' is avoided in the case of rice.

(v) The area under jute and other bast fibres may be added to rice group.

(vi) The Andhra Pradesh area under tobacco may be added to rice group and the rest may be divided equally between the wheat and millet belts.

(vii) The total area under sugarcane in 2000 AD, will be 5 M ha. This may be apportioned among the three areas as follows : wheat belt 3 M ha, millet belt 1.5 M ha and rice areas 0.5 M ha.

(viii) Sugarbeet area may be added to wheat belt, as most of it is going to be situated in the northern parts.

(ix) The area under vegetable and fruit crops may be divided among the wheat, rice and millet areas proportionately.

(x) The area under plantation crops may be added to paddy group, because most of the plantation crops are grown in the heavy rainfall areas.

3. On the above basis, the gross cropped area of the country in 2000 A.D. will stand divided among the three main areas as indicated below :—

rice areas	=	75 M ha
wheat belt	=	51 M ha
millet belt	=	74 M ha
total		200 M ha

The area gap of 30 M ha not accounted for by the draught animal power could be apportioned to rice, wheat and millet areas in the ratio of 3:2:3, which would work out approximately to 11 M ha, 8 M ha and 11 M ha respectively.

4. The cultivated area which a tractor can command depends upon two factors, viz., (a) its power and (b) whether it is going to the sole motive power or it is used in association with bullock power. Till now, both have gone hand-in-hand except for very highly mechanised farms which are very few. Therefore, the area expected to be commanded with a tractor when used as a supplementing source of power is higher than what it could command if used without animal power. However, the present calculations are being made to arrive at the number of agricultural tractors which would be required for bridging the power gap in 30 M ha of net cultivated area that would not be covered by the draught animal power. Therefore, for calculation purposes, tractor would be considered as the sole prime mover in this area, although in practice the blend of animal and machine power would continue to occur everywhere even in future. When tractor is the sole prime mover, the area which it could command would be less : for this reason, the following norms are assumed :

Tractor type	hp	Suitable farm size (ha)
2-wheeled walky type power tiller . . .	5—10	5
4-wheeled power tiller (light tractor) . . .	10—20	25
4-wheeled medium tractor . . .	20—50	50
4-wheeled heavy tractor . . .	50—80	100

5. The requirement of tractors on the basis of above mentioned assumptions is shown in the following table :

Tractor type	Rice areas		Wheat belt		Millet belt	
	for how much area (M ha)	number (million)	for how much area (M ha)	number (million)	for how much area (M ha)	number (million)
2 wheel power tiller @ 1 per 5 ha	7	1·40	1	0·20	1	0.20
4 wheel power tiller @ 1 per 25 ha	2	0·08	3	0·12	2	0·08
medium tractor @ 1 per 50 ha	1	0·02	2	0·04	3	0·06
heavy tractor @ 1 per 100 ha	1	0·01	2	0·02	5	0·05
total	11	1·51	8	0·38	11	0·39

6. The allocation of area for which a particular type of tractor has to be provided is subjectively derived in the above table, the basis being approximately the power needs of main crops in the three tracts. For example in rice areas the emphasis is on 2 wheel powertillers in millet belt, which contains the black cotton soils and where the maximum need is for timely completion of sowing and harvesting operations over vast stretches of land depending upon the arrival of rains, the emphasis is on providing heavy and medium types of tractors. Garden type light tractor has been provided in sufficient numbers every where because of its suitability for lighter jobs, small holdings and less cost. Wheat belt contains the plateau areas of the central parts where working of the soil is more difficult than in the plains and it also contains the main sugarcane areas, which also require heavy tillage. Owing to these two reasons, more provision for heavy tractors has been made in this belt than in the rice areas. The position of power requirement on the basis of demand for tractors as shown in the table of the previous paragraph will be of the following order :

Tractor type	Number (million)	Capacity per tractor (hp)	Total power (million hp)
2 wheel power tiller	1·80	7	12·60
4 wheel power tiller	0·28	15	4·20
4 wheel medium tractor	0·12	35	4·20
4 wheel heavy tractor	0·08	65	5·20
total	2·28		26·20

51

IMPLEMENTS AND MACHINERY

1 Introduction

51.1.1 It is only through tools, implements* and machinery that power can be used for carrying out various farm operations. Indigenous implements and machinery that are in use in the country have been evolved over generations and may resemble ancient ones. It is being increasingly realised that use of improved implements and machinery can result in increased production and at the same time reduce drudgery. No single appliance can meet all farming situations. The implements and machinery will have to be of different sizes and shapes to perform various operations under varying conditions most efficiently and expeditiously. The various aspects of farm power are dealt with in Chapter 50; in this chapter we deal with implements and machinery that go with various power sources.

51.1.2 The essential implements used in Indian agriculture are *khurpi*, sickle, spade, pickaxe, *desi* plough and *patela*, (the plank used for clod crushing and levelling). The farmer has also been using various local models of hoes, harrows, cultivators, seed drills etc.; a few of them are shown in Appendix 51.1. The *desi* plough has been his most indispensable implement in the field. There was an attempt to introduce mouldboard iron ploughs in the country towards the close of the nineteenth century. In this context, the observation made in 1893 by J. A. Voelcker, who acted as an adviser to the then Government of India for improving agriculture through scientific means, is pertinent. He was of the opinion that the imported iron ploughs were heavy and difficult for weak animals to pull. Moreover, he felt that the double handles in iron plough were inconvenient for the farmer as he had to hold in addition the hitch rope also. To him the indigenous plough was 'ingenious' and he favoured its improvement. He also felt that large scale trials were needed with the imported implements before their adoption.

*For the sake of brevity, the term 'implement' will connote 'tool' also.

51.1.3 Efforts towards developing better implements began in 1900 with the involvement of L. K. Kirloskar, the founder of Kirloskar Company which specialised in the manufacture of agricultural implements and machinery. The first set of six ironmould board ploughs was manufactured by him at his Belgaum (Karnataka) workshop in 1905, but it was a strenuous job to make them popular. The picture had not altered much even by the time of the Royal Commission on Agriculture (RCA) (1928), which laid emphasis on the mass production of a cheap iron plough easily pulled by bullocks in order to do away with the tedium inherent in the use of *desi* plough. It also recommended development of seed drills for line sowing, interculture equipment, animal driven sugarcane crushers, diesel pump sets and other water lifting contrivances hand chaff cutters and extensive use of pneumatic tyre bullock carts for easier transportation. Some idea of subsequent progress can be had from the annual reports of the Agricultural Departments. For example, power threshers mowers with reaping attachments, disc harrows and seed drills were reported to have appeared during 1929-30 in some farms in Bihar largely through imports. In the beginning of thirties, some *sukhda* cultivators for hoeing in surgarcane fields and *rahat* for lifting water were demonstrated and supplied to willing farmers. Bihar junior and Bihar senior three roller power cane mill, engine for pumping water and *noorag* bullock threshing machines also began to be used. Another example could be given for the then Bombay Province, where the Agriculture Department extended demonstrations to farmers' fields specially for popularising an improved seed drill. It was reported to be acceptable to farmers because it was lighter both in dead weight and draught weight and was easy for pulling by even weak cattle. The Department of Agriculture also devoted considerable time in the development of a winnower during 1931-32. Other advancements related to the development of cart wheels with ball bearing for lighter transport and a groundnut digger. Similar activities could be mentioned for other Provinces too, but a feature which could be noted was that there was no coordination either with the Centre or among the Provinces.

51.1.4 The RCA had recommended the creation of an engineering cell in every provincial agriculture department. Gradually a pattern got built up, according to which the Provinces and some major princely states had an agricultural engineer within the agriculture department. He was generally located at the agricultural college, if it existed in the Province or State. Whatever improvements in implement took place were the results of his efforts, but the emphasis

by and large was on heavy machinery and boring of wells. The picture continued like this more or less up to the advent of Five Year Plans, whereafter began a period of giving gradually increasing attention to developmental work on implements. Initial empasis was on the introduction of improved hand operated chaff cutters and winnowers and animal drawn implements such as mouldboard ploughs, cultivators and seed drills. The Planning Commission had also been emphasizing during the First and Second Five Year Plans the need for establishing in every State a separate section to carry out research on indigenous implements and tools. The Indian Council of Agricultural Research (ICAR) accordingly convened a conference on agricultural implements and machinery in January, 1953. The conference felt the need for a survey of indigenous implements as a first step. Consequently, a scheme to undertake such a survey was sanctioned by the ICAR in 1954. The work was completed by the end of 1958[1]. It was pointed out that the main problem in the fabrication of indigenous implements was the variation in their sizes and shapes without there being any standard. There was need for their improvement and standardization, which were required to be done in a coordinated manner taking into consideration various agro-climatic conditions. It was particularly felt that a committee should be set up to consider standardization of shapes and sizes of the components of some selected implements for manufacture on a mass scale. It was also suggested that the implements should be such that they could be repaired locally. In the case of mouldboard ploughs, there was need to evolve suitable methods whereby multiple teams of draught animals pulling such ploughs could be managed by a single person, as against many required now.

51.1.5 Soon after the release of the 1958 survey, the ICAR sanctioned a scheme to test the available implements and design new ones for operations not already covered by the existing ones and for popularising the same. A start was made by establishing research testing and training centres (RTTC) at the Indian Agricultural Research Institute (IARI) and at Burdwan, Poona and Coimbatore. In addition to these four, thirteen more research centres were established between 1963 and 1965 at Srinagar, Mandi (Himachal Pradesh), Ludhiana, Kanpur, Doli (Bihar), Shillong, Bhubaneshwar, Jaipur, Junagarh, Jabalpur, Rajendranagar (Andhra Pradesh), Bangalore and Trivandrum. This gave a distribution of one centre per major State. The work at these centres began with testing and introducing imple-

[1] 1960. [Indigenous Agricultural Implements of India, An All India Survey, Indian Council of Agricultural Research, New Delhi.

ments like Japanese ploughs, disc harrows, tyned cultivators, paddy weeders, bund formers, hand tools for hill areas, seed drills, Japanese threshers, power tillers, decorticators, graders and maize shellers. Design work on new implements included groundnut planter, power thresher (low hp), paddy transplanter, multi-row seed-cum-fertilizer drills for different crops, potato digger and tool bar frame. All this work continued since then. During the Fourth Plan period the control of most of these centres was transferred to the States excepting for the ones at the IARI and at Coimbatore, Ludhiana, Poona and Rajendranagar, which had continued to be the ICAR's responsibility. The centres at the IARI and Coimbatore act as zonal research centres, whereas the other three are retained for specific purposes, e.g., Ludhiana for harvesting machines for wheat and root crops, Poona for dry land implements and Rajendranagar for wetland implements. The research centre at Mandi had concentrated on hill area implements. In some of the States, these research centres were merged with agricultural universities, whereas in others, they remained separate. The specialized central institutes of the ICAR like the Central Rice Research Institute, Cuttack, Indian Institute of Sugarcane Research, Lucknow, Central Potato Research Institute, Simla and Indian Grassland and Fodder Research Institute, Jhansi look after problems pertaining to machinery and implements specific to the respective crops and regions. The Indian Institute of Technology also undertakes research work on agricultural machinery and implements. With the reorganisation of the ICAR in 1966 and the initiation of various coordinated projects subsequently, research on implements has been included in the scope of some of the projects.

51.1.6 We have mentioned in Chapter 50 on Farm Power that there is a satisfactory administrative setup at the Centre to deal with farm machinery. Matters relating to agricultural implements, machinery, agro-services including agro-industries are all handled in the Machinery Division of the Ministry of Agriculture and Irrigation. There is also a high powered Board of Agricultural Machinery and Implements functioning within the Ministry to keep a watch on the progress of modernisation and increasing use of farm machinery and implements and suggest appropriate measures. We have suggested a parallel strengthening of the agricultural engineering setup in the States up to the block level and measures to train the required staff. A Central Institute of Agricultural Engineering has already come up. Three well-equipped tractor testing and training centres are also expected to come up. Most of the States have got a RTTC dealing with farm machinery and implements.

51.1.7 Another important landmark in the field of agricultural implements in recent times was the survey of the industry by the Panel of Agricultural Implements set up by the Ministry of Industrial Development in July 1967. Its main objective was to examine the status of the agricultural implements industry with particular emphasis on the small sector. Its terms of reference and recommendations are reproduced in Appendix 51.2. The report submitted in 1973 had highlighted almost all important aspects[1]. The panel observed that one of the reasons for agricultural implements of various kinds not becoming popular in rural areas was the lack of service facilities and suggested that engineering diploma holders and technicians coming out from the industrial training institute (III) should be encouraged to open service centres in these areas. As existing units manufacturing agricultural implements were not even utilizing 50 per cent of their capacity, the panel was of the view that no further capacity was required for manual and animal drawn implements for some time to come. Creation of new capacities should be restricted to sophisticated and new implements and processing machinery. It was of the opinion that large scale units should obtain their requirements from ancillary small scale units and agro-industries corporations should not compete with the small scale sector in the manufacture of implements. In order to assist this sector, the small industries development corporations and agro-industries corporations have to stock necessary raw materials and supply the same to the manufacturers at reasonable rates. This is because the main raw materials like pig iron, B. P. sheets, G. P. sheets, high carbon steel sheets, mild steel sheets, rods, flats and angles are all in short supply and high carbon steel sheets have to be imported. In order to reduce the burden on manufacturers and at the same time encourage standardisation, the panel recommended that the Indian Standards Institution (ISI) should reduce its various fees. Only ISI-marked implements should be purchased or financed by government and semi-government or related organisations. The banks should be in a position to finance the purchase of even small value implements. There was need for greater coordination between research institutes and ICAR on one side and the Ministry of Industrial Development on the other. Improved implements from all over the world should be procured for encouraging the manufacturers to make prototypes. For export survey, the State Trading Corporation (STC) and Engineering Export

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1. 1973. *Report of the Panel on Agricultural Implements*, New Delhi, Office of the Development Commissioner, Small Scale Industries of the former Ministry of Industrial Development, Internal Trade & Company Affairs.

Promotion Council (EEPC) could make a market survey in foreign countries.

51.1.8 The deliberations of the Panel covered many essential points relevant to manufacture of implements in the small sector. We are in agreement with all their recommendations excepting two, viz., one in which they desire to rule out completely the participation of agro-industries corporations in the manufacture of implements and the other in which they advocate dependence upon foreign implements for adapting them in this country. We will have occasion to put forth our views on these two issues in appropriate places. The Panel has drawn up a list of machinery which it considers suitable for wide acceptance. Many of the items included refer to tractor drawn equipment. In fact, there is a big slant in the thinking of experts and officials alike in this country even in general in favour of tractor drawn machinery. We observe a general mix of the manual and animal driven implements and machinery on the one hand and tractor driven machinery on the other—whether in research programmes or otherwise—and in this mix the former has always been given second place. Chapter 50 on Farm Power would show that a great number of men and draft animals would remain involved in farming operations even by 2000AD and it is therefore necessary that the required number of quality implements and machinery continue to be available. We have, therefore, chosen to devote the next section entirely to the problems of such implements and machinery.

51.1.9 We may ask at this stage about the impact of improved implements on Indian agriculture in general so far. Undoubtedly, some of the areas like Punjab-Haryana and adjoining parts of Uttar Pradesh and Rajasthan and parts of Gujarat and Tamil Nadu have taken to modern appliances on a large scale. The suburban areas, villages situated in the neighbourhood of government farms, institutes, colleges and agricultural universities; and villages covered by special development programmes like the Intensive Agricultural District Programme have had opportunities to adopt improved implements. However, majority of farmers remain untouched by the new innovations. To them, *khurpi*, pick axe, spade, *desi* plough and the old wooden 'plank' still constitute the main kit for agricultural operations. Even other better placed or enlightened farmers place considerable reliance on this basic unit of implements. Leaving aside costly or sophisticated implements, even the wooden beamed light mouldboard plough like the Meston did not become as common a possession as the *desi* plough. Thus, there is a big gap between the prevalence of the age-old implements on the one hand and the

acceptance of modern tools on the other. It is often said that the farmers have been orthodox in this respect. This is not so, because the Indian farmer has been quick enough to accept modern technology wherever he got convinced of its utility under his circumstances. He has accepted the improved seed. There are farmers who have not been found wanting to pick up even the intricacies of hybridization work. Within the field of implements itself, they are accepting the chaff cutter, plant protection equipment and pumping sets. The wooden *kolhu* has easily given way to iron *kolhu* and in wheat belt, the improved thresher is also becoming popular. In fact he is ready to accept anything which he can manage with readily available resources. Better implements are neither available to him so easily nor is there any arrangement for their replacement and repairs in or near his village.

51.1.10 It would be interesting to examine the position of some places where mechanisation in particular has made significant inroads. With this purpose in view, the position of maintenance and repair service of agricultural implements and machinery in three selected districts of Punjab was studied at the Punjab Agricultural University at the instance of the Commission. The study has shown that there is a mushroom growth of repair service institutions, most of which are unlicensed. Only about 11 per cent of the entrepreneurs were found to be graduates with or without the requisite knowhow and their establishments were usually situated in towns. Most of the others were small or medium class establishments manned by unskilled or self-trained, semi-skilled artisans, who took the opportunity of filling in the void by opening their workshops in villages. Nearly one third of such service units are engaged in tractor repairing alone, while another one third repaired various kinds of farm machinery as well as tractors. There are still other units, nearly 15 per cent of which repaired automobile and undertook tractor repairing as a supplementary job, while 17 per cent were exclusively engaged in repairing electric motors and diesel engines. It is quite revealing that hand tools and bullock driven implements and machinery are neglected. It does not, however, mean that the service for tractor drawn machinery is any better. The emphasis in the existing workshops is mainly on tractors. In fact, the workshops have come up due to tractors only. On enquiry, the farmers have expressed themselves in favour of more organised and reliable services and would opt for service centres sponsored by the agro-industries corporations, universities or any other departmental agencies. They feel that the units should be located near their villages, spare parts should be available at cheaper rates and mechanics should be skilled enough to offer reliable and timely service.

These views will also be duly considered by us in the succeeding discussions.

2 HAND OPERATED AND ANIMAL DRAWN IMPLEMENTS AND MACHINERY

51.2.1 An increase of available power has been suggested in Chapter 50 on Farm Power in order to improve production standards. It is not just the increase of power that is important but what matters is the type of implements and machinery through which power is applied in performing various operations. Some of the improved implements can be 5 to 10 times more efficient in energy conversion while performing operations as compared to primitive tools and implements commonly used by farmers since ages. The deficiency of power will be less pronounced if the indigenous implements are substituted by improved ones which are more efficient. It is, therefore, necessary not only to increase the power input but also introduce efficient matching implements and machinery. The All India Livestock Census provides data regarding the number of various implements and machines in use in the country. Until 1961, enumeration was done with regard to wooden and mouldboard ploughs, sugarcane crushers, bullocks carts, oil engines, electrically operated pumps and tractors. More items like improved harrows and cultivators, improved seed drills, rotary chaff cutters and sprayers and dusters have been added since the Census of 1966. Relevant data for the 1972 Census have not yet become available; hence data for 1966 are presented in the Table on next page:

TABLE 51·1

Different types of farm Implements and Machinery as revealed in Livestock Census

(million)

Type	1951	1956	1961	1966
1	2	3	4	5
wooden plough	31·80	36·14	38·37	39·88
iron plough	0·93	1·38	2·21	3·52
bullock cart	9·86	10·97	12·07	12·69
bullock driven cane crusher .	0·54	0·55	0·59	0·65

TABLE 51·1 (Contd.)

1	2	3	4	5
Powerdriven canecrusher . .	0·021	0·023	0·033	0·045
improved harrow and cultivator .	..	..	..	2·72
improved seed drill . .	..	..	..	1·14
improved thresher . . .	..	..	..	0·37
rotary chaff cutter . . .	..	..	..	4·73
sprayer and duster . . .	..	..	..	22·11
Persian wheel or rahats . .	..	..	0·60	0·68
diesel pumpsets	0·082	0·12	0·23	0·47
electric pumpsets . . .	0·026	0·047	1·60	4·15

It will be seen from the table that even today there is predominance of traditional implements particularly the wooden plough and that the number of improved types in use is comparatively small. The reason for the situation as stated earlier has to be found elsewhere than conservative attitude of farmers. Paucity of supply and service facilities has appeared to be one of the reasons. Although survey of indigenous implements was conducted all over the country during 1950s, it was not done with a view to assessing reasons for the slow spread of improved implements and machinery. We recommend that a detailed survey should be undertaken as early as possible to find out the reasons for the slow acceptance of improved types of implements and machinery and the continued preference to wooden plough. The present position with regard to some important implements and tools is discussed in the following paragraphs.

Tillage Implements

51.2.2 Land has to be tilled with various implements and tools to create a favourable soil condition for germination of seeds sown and for proper growth of plants. This is being done with hand tools like pickaxe and spade in hilly and inaccessible areas even today and elsewhere with bullock drawn implements like plough, shovel tooth cultivator and blade harrow or with tractor drawn implements

of similar kind. It is considered that heavy primary tillage is not required in hot climate, because natural processes are intense. Even then soil is required to be broken in order to collect and store as much moisture as possible in semi-arid and arid areas. Natural tilth and moisture is preserved better in tropical conditions with good natural vegetation. In humid areas, however, it has been considered necessary to have deep tillage preferably accompanied by soil turning. Experiments conducted, though few, in different parts of the country confirm this view in general.

Ploughs

51.2.3 Plough is the basic implement that is available with almost every farmer in the country and ploughing is the operation that consumes maximum energy. According to Roy[1], 70-75 per cent of the total energy expended in field operations is consumed by this implement alone and it absorbs an estimated 35-40 per cent of the total energy on all agricultural operations in India today, with an extremely low efficiency of energy conversion into useful work. The earliest plough was just a crooked and forked branch of a tree. Wooden plough shod with small piece of iron is a common implement in the country. Although the basic structure remains the same, considerable variation is observed in size and shape of different parts of ploughs obtaining in different regions of the country. Plough used in paddy regions is the smallest in size and that in heavy black soil areas is the heaviest. A very heavy type of plough was in use in Sholapur district in Maharashtra, which was operated by as many as 4-5 pairs of bullocks. Such heavy ploughs are almost extinct now and are replaced by iron ploughs pulled by 3-4 pairs of bullocks or by tractor ploughs. The wooden plough commonly used now in the country is operated by a pair of bullocks. The Livestock Census (1966) data indicate that 90 per cent of the ploughs in India even today are of ancient types and have undergone little change for ages. Attempts made to introduce iron ploughs during the last 75 years have not been very successful in replacing wooden ploughs. Iron ploughs of various sizes are available in different regions of the country. One of these, viz., the turnwrest, is shown as an example in Figure (b) of Appendix 51.3. These ploughs are 2-3 times more efficient than wooden ploughs of equivalent draft. Except in some pockets they have not been generally popular for various reasons. To get the same degree of tilth that is obtained with a single ploughing with iron plough, one would

1. 1970. Roy S.E., *Agricultural Engineering*: Agricultural Year Book, New Vista in Crop Yields, 510-568, Indian Council of Agricultural Research, New Delhi.

have to work the *desi* plough 4 times at least and this requires 3 times more time and energy. Since it takes more time to prepare the land with wooden plough, sowing operations are delayed. When sowing of wheat is delayed by a day, yields are likely to get reduced by about a quintal per hectare in place. In spite of proven advantages in favour of iron plough, wooden plough continues to be used by the large majority of farmers in the country. The probable reasons are that wooden plough is a multipurpose implement and can be made, repaired and maintained by local artisans; it is simple in construction and is made of locally available wood except for a piece of iron that is used as 'share'. Another important factor is that it is cheap.

51.2.4 Sufficient research work has not been carried out to improve the wooden plough. One of the attempts made was to prepare the entire body of cast iron maintaining the shape as that of common wooden plough. It became heavy and did not become very popular. Another attempt was to make the bottom of the body flat so that V-shaped furrows are not formed. This attempt also was abortive and the model remained as an experimental one. In the initial stages all the attempts were concentrated on introducing imported horse drawn types of iron ploughs. In later years, however, new designs to suit the local conditions appeared on the market. The most important contribution made by the manufacturers in India is the development of turnwrest plough in place of fixed mouldboard type which can be worked by 'to and fro' method instead of by 'round and round' method. Fixed mouldboard types no doubt have an advantage as far as quality of work is concerned, especially with regard to turning act, but there was considerable resistance to the method of operating it. As a result, the fixed types did not become popular except in some pockets of the country where the method of ploughing adopted by farmers was normally going 'round and round'.

51.2.5 Ploughing will continue to be done in the country with bullock power for many years to come. We have estimated that the number of draught animals in 2000 AD is likely to be the same as at present. Bullock drawn plough will, therefore, remain an indispensable implement on farms in India. It is, therefore, necessary to devote more attention to the improvement of wooden plough or to the replacement of the same with a more acceptable iron plough. Intensive surveys should be carried out to understand the reasons why wooden plough is still popular in preference to iron plough. When farmers in some regions have accepted iron plough, there is no reason why it should not be accepted in other regions. High price cannot be said to be the sole reason, since some recommendations on improved agricultural practices that involve higher financial investments have

been adopted by farmers. Want of repair, supply and service facilities also cannot be said to be the whole reason. When such facilities have been built up in some areas, it is difficult to explain why the same cannot be organised in other areas. One of the main reasons appears to be that the advantages of using iron plough in place of wooden plough have not been convincingly demonstrated to farmers in various regions. Both research and extension efforts are wanting in some respects. Efforts to develop suitable types of the plough for different conditions in order to replace the existing wooden plough will have to be made on a giganitic scale and the required research, manufacturing and extension organisations will have to be built up. Similarly, the local artisans will have to be trained to repair and service the new types of ploughs.

Seed Bed Preparation Implements

51.2.6 Ploughing leaves the land cloddy, loose and uneven. Seed cannot be deposited in soil in such conditions. The soil is required to be worked further after ploughing with various implements to crush the clods if any, level and smoothen the land and prepare firm and compact seed bed free from weeds with crumb structure at the top. The various implements used for this purpose are grouped under seed bed preparation implements. These consist of harrows, clod crushers, levellers and smootheners.

Harrows

51.2.7 Blade Harrows* are used to prepare the land in some areas instead of ploughs. Harrows are common in Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. It is a common implement in dry or semi-arid regions of the country especially in black and medium black soil tracts. It is a good implement for secondary tillage, i.e., for breaking clods and smoothening. It is a very good implement for preplanting weed eradication. The ground, however, should be free from stones and big roots. It is an effective implement for creating mulch after rains and for destroying weeds. In some tracts, harrow is preferred to plough for primary tillage, especially in deep black soils. It is an unique implement of this country. There is no improved implement which can perform similar work as blade harrow. Some of the improved types

*For example, please see Twin Blade Harrow (Cuddapah) and Blade Harrow (Gura) in Appendix 51.1.

like tyne tooth harrow, spike tooth harrow, shovel tooth cultivators (Figures (a) and (c) of Appendix 51.3) are good for carrying out special operations, but blade harrow is a general multipurpose implement in the tracts mentioned earlier. Surprisingly enough, blade harrow is not to be found in the northern alluvial tracts and also in heavy rainfall areas. It may not find a place in paddy areas, but it should be advantageous to introduce it in alluvial areas. Reasons why useful implement like blade harrow is not finding a place in northern part of the country should be assessed and attempts made to introduce blade harrow either of existing type or modified ones.

51.2.8 Disc harrow was introduced in the country some years back. This is also an useful implement, but has not become popular over large areas. Only in some parts like Punjab, it has been observed to be in use. Tractor drawn disc harrows have become popular where tractors are in use. Discing is done in place of ploughing to prepare land quickly. It is proved sufficient for majority of annual rainfed crops. Discing gives good results when heavy trash is left over after harvest of crops.

Clod Crushers

51.2.9 Clod crushing may not be always necessary in rainfed farming areas since rain takes care of the same, but in irrigated areas and also in the areas where seed deposition is done in dry soils in anticipation of rain as is common in drilled paddy region, clod crushing assumes considerable importance. In some areas clod crushing is done by using mallet. To break clods with this tool is a very laborious and back breaking operation. Complete job is not done in one operation. It has to be repeated 3 to 4 times after raking cut the clods. Planks of various kinds are also used to break clods; these are inefficient and incovenient for both the workers and bullocks. An improved implement called Norwegian harrow was introduced with limited success (Figure (d) of Appendix 51.3). It is really one of the best implements for clod crushing. It consists of a rectangular frame mounted on three wheels. On the rear side of the frame are fixed two square axles one behind another. On each of the axles cast iron stars with five tapering spikes are fixed. The number of stars varies from 12—20 in each gang. The stars are fixed in such a way that there is continuous rolling action without jerks. This implement is still found in a few hundreds only in the Deccan Canal tract. An attempt was made to fabricate a simple one consisting of solid wooden cylinder with iron spikes of 8—10 cm in length fixed on it. Such an implement known as roller with spikes is in use in some drilled paddy

tracts (Figure (e) of Appendix 51.3). Disc harrows or tyne harrows are usually used for clod crushing behind a tractor.

Levellers

51.2.10 Levelling is one of the occasional land development operations. Various indigenous levellers are in use in the country. A simple one made of bamboo known as *petari* is popular in west coast paddy tract. Plank levellers of various sizes and shapes are common all over the country. In some parts blade harrow itself is used as leveller after putting a plank or rope between head piece and blade. A number of improved types have been developed and are in use. Iron leveller is good for moving soil from a high-lying spot to a low-lying spot. It is a bucket type land scraper. Improved plank levellers are being popularised in irrigated areas especially in Karanataka, Maharasthra and Rajasthan. In recent years bulldozers and graders are also being used. But the number of suitable implements in use at present for levelling is too small to create any impact. It is, therefore, common to observe uneven growth of plants in the same field because of uneven distribution of rain as well as irrigation water. Land levelling is one operation which is required to be carried out in irrigated as well as rainfed areas. Except for paddy, levelling is not considered to be very necessary for other crops; this impression is required to be removed. More attention has to be paid to this operation all over the country to ensure more efficient water management under irrigated as well as rainfed conditions.

51.2.11 Compacting of soil is necessary if it is too loose and where firm seed bed is desired. Various kinds of roller and planks are used for smoothening the soil before sowing. This operation is conveniently carried out with planks in India. Rollers are not common. Various kinds of rollers like cultipacker, T-bar roller etc., are used in foreign countries, but none of them are commonly used in India. An improved implement known as 'float' is being popularised for final smoothing and packing the soil before seeding. It is very useful for irrigated farms.

Tillage Implements in General

51.2.12 The implements frequently in use in the country for the preparation of land are not efficient enough to reduce the drudgery and power requirement. Lot of power is wasted in carrying out these operations, and that too inefficiently. As a result, yield levels are low

and cost of production is high. Research work done on this aspect is not sufficient. Neither the engineer nor the agronomist is much interested in these aspects of crop husbandry. As a result land is being prepared by age old methods with inefficient implements all over the country. The job that is required to be done by paddy growers in preparing the land either for dry sowing or for transplanting is so arduous and labour consuming that sowings are invariably delayed, resulting in low levels of yields. Delays in sowings occur in the case of other crops also because of similar reasons. There is considerable scope for bringing about improvements in the implements themselves as also in the sequence of operations. Considerable work has been done in other countries on the minimum tillage concept. Improvements have been brought about in the land preparation for paddy. Weed-free seed bed with appropriate tilth is difficult to achieve. In areas with distinct wet and dry periods as obtain in the country, tillage time is very limited. Timeliness in completing the basic land preparation before planting is usually very crucial. We therefore recommend that more attention be paid to research on improvement required in implements and also in the entire system of land preparation suited to different regions of the country.

51.2.13 The next steps would naturally be to make the improved implements available and to popularise their use. This requires a strong extension organisation backed by an appropriate supply and service organisation. As some of these implements will be required only occasionally, only a few farmers will like to own them. Therefore these implements will have to be made available on a certain hire basis and this has to be at village level for early availability to farmers either through societies or service centres. Attempts made in this regard have not yielded desired results. One of the reasons was that the number available for hire was very small and a few influential persons cornerned such implements for their own use. The situation is required to be improved considerably, so that every farmer may have access to improved implements.

Seeding Implements

51.2.14 Establishment of crops in a field is the most important operation in farming. Methods and timeliness of sowing greatly influence germination, seeding growth, weeding requirements and operations and final yield. If a proper stand is not obtained, the expenditure on land preparation, seed, manure and other operations is as good as wasted. Seed has to be deposited in soil in such a

way as to ensure complete germination and proper growth of plants. Seed can be deposited in soil by broadcasting, drilling or dibbling. Broadcasting is the simplest and crudest method of the three and is advantageous under certain circumstances, but is wasteful. Drilling is an improvement over broadcasting and the seeds are dropped in lines. Dibbling is a perfect method if done properly but costly, although cost on weeding would be considerably reduced. Some crops are established by transplanting seedlings. Transplanting has a number of advantages. Smaller quantity of seed is required and it is easier to take care of seedlings in seed beds. It also provides opportunity to select healthy seedlings at the time of transplantation. Some crops are vegetatively propagated using plant parts like rhizomes, tubers etc.

51.2.15 The usual method of broadcasting seeds in India is by hand. Experienced farmers do a good job of broadcasting. The job can be better done with broadcasting implements like knapsack or wheel barrow broadcast seeders. (Figure (f) and (g) of Appendix 51.3). Knapsack broadcaster is a simple tool with a bag to hold seed with an opening to allow the flow of seed and a fan to receive and spread the seed. Hole size is adjustable to regulate the seed rate. Wheel barrow type consists of seed box and a rod vibrator closing the slit at the bottom of the seed box. Seed is dropped and distributed along the length of the box due to shaking action of the vibrator. Improved broadcasters have been imported but have not become popular. They could, however, be used with advantage in reseeding operations in grass lands.

51.2.16 Drill is a machine designed to drop seeds in soil in chain at a uniform depth. The indigenous drill is another unique implement which is simple in construction and operation and quite cheap: the quality of work done is fairly satisfactory although much depends on the skill of the operator. Attempts made earlier to improve the indigenous types or to replace them with imported types have not been very successful. Improved drills have automatic seed dropping, seed covering and compacting arrangements. Only in recent years tractor drawn drills are being used in areas where tractors have been introduced. Although indigenous drill is far from being ideal, there is no improved implement which can replace it. There are various kinds of indigenous drills in the country. Some are two coultered and others have anywhere from 3 to 6. Drills used in kharif season are lighter as compared to those used for sowing rabi crops.

51.2.17 The usual method of dibbling seeds in India is to make a small hole to a desired depth by means of *khurpi* or a wooden peg

and drop a few seeds at each spot and cover with soil by hand. Simple hand planter for maize planting was introduced and popularised in some tracts. Simple bullocks drawn, single and multi row planters were also introduced, but they did not become popular because of high cost and complex designs.

51.2.18 It is interesting to note that more than 80 million hectares of cropped area under food grains in the country are still sown by broadcasting. The seed rate required to be used for getting a proper stand is much more when seed is broadcast than when it is drilled or dibbled. Just by changing over from broadcasting to drilling, it is estimated that as much as 4 million tonnes of seed could be saved. Various kinds of indigenous drills are in use in the States of Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu, but in other parts drills are unknown just like blade harrows. It should be possible to introduce appropriate types of drills and train local artisans to manufacture them and farmers to use them. Some efforts have been made in the past, but not serious enough looking to the gravity of the situation. Renewed efforts should be made to adapt suitable types of drills for different regions and popularise them in the areas where they are not in use at present. Further research to improve them should be intensified in all agricultural universities. This should be one of the main items of research in the agricultural engineering divisions in collaboration with agronomy division. Improvement in seeding methods will ensure a uniform stand in all crops and this by itself will result in considerable improvement in yield levels and at the same time reduce expenditure on weeding. Suggestions from local artisans should be invited by giving publicity on widest possible scale and also by announcing maximum possible rewards. Local talent should be tapped. Many significant improvements have been suggested by farmers in foreign countries, which have been adopted by scientists.

51.2.19 A number of crops like paddy, tobacco, chillies etc., are transplanted. Transplanting of paddy is a very arduous and time consuming operation. In recent years, transplanting of paddy is being done in Japan using mechanical transplanters. They are costly and are complicated in design. A paddy transplanter designed by a gramsevak in Orissa has been introduced in paddy areas recently. If successful, it will enable withdrawal of women from transplanting work, which is highly time consuming and laborious. For want of sufficient labour for paddy transplanting, plantings are delayed and this results in considerable reduction of yields. The newly designed implement works satisfactorily and it is being tested in different paddy growing States. It deserves serious trial. With further improvements on vari-

ous engineering aspects in the hands of engineers, this implement has great potentiality. Further trials and improvement should be continued to make it acceptable in all paddy growing areas.

Weeding and Inter-cultivation

51.2.20 Weeds have always been a matter of concern to the farmer. These compete with the crop for nutrition and space. Because of both these factors, the development of crop plants suffers resulting in lower yields. The farmer has to fight the weed menace year in and year out. This job is particularly difficult in the rainy season when weeds are profuse and grow rapidly and more so in closely spaced crops where weeding operations are not that easy. We attach great importance to the means by which weeds could be removed and the space provided between crop plants. The main tool used for weeding and intercultivation is a simple *khurpi*. This is a universal tool in India. It is opined that this tool is responsible for the bondage of millions of men, women and children for many days in a year in an operation of extreme drudgery. Roy[1] estimates that 12—15 thousand million horsepower hours of human labour is spent on weeding through *khurpi*, which performs the operation most inefficiently. One of the reasons why human labour is required to be employed for weeding operation with *khurpi* is that crops are sown broadcast in vast areas. Line sowing or drilling will help in reducing not only the drudgery of the operation but also the use of human labour. Useful and simple hand operated weeders have been developed and recommended. These tools with long handles can be worked standing and with ease. More areas can be covered in a day. Drudgery is reduced. Even then, these tools have not become popular. It is possible to reduce the use of hand labour further by adopting chemical method of weed control. New selective weedicides are becoming increasingly available which can be used with considerable advantage in raising crops in almost weed free conditions.

51.2.21 Bullock drawn implements are used in those parts of the country where crops are sown or dibbled in lines. These implements are used mainly to till the space left in between the rows of crops. Inter-cultivation helps in loosening the pulverising soil and removing weeds. Inter-cultivation can be started earliest with slit blade hoes* and continued with entire blade hoes, until the crop plants spread and cover the entire field. Considerable importance was attached to this

1. *Ibid*, 1 (566).
*Please see Blade Hoe (Khargone) in Appendix 51·1

operation in earlier years. Creation of dust mulch was advocated then by inter cultivating with various kinds of implements as often as possible. With the disproving of mulch theory, cultivation was suggested to be done to the extent needed to keep the weeds under check. With the coming in of weedicides, its importance is further reduced and the present trend is to resort to it to the minimum extent needed to loosen soil for the better moisture conservation.

51.2.22 Indigenous blade hoes are similar to blade harrows in construction. Improved types of cultivators include tyne tooth and shovel tooth cultivators. Tyne tooth cultivators are good for just stirring the soil to break the surface soil crust. Shovel tooth cultivator has a number of attachments with which various other objectives like earthing up, deep inter tillage, opening of furrows for irrigation, etc., could be achieved. None of the improved types have become popular. Interculturing implements are used only in areas where crops and drill-sown and widely spaced. Considerable importance is attached to this operation in Gujarat and other States in black soil tracts.

51.2.23 The use of implements for inter-cultivation is advantageous in many ways and hence should be popularised along with drill sowing or dibbling. Drudgery of hand weeding which is usually done by women can be reduced to a considerable extent by adopting line sowing or dibbling and use of chemicals for weed control and/or carrying out inter-cultivation with suitable implements. There is also need for carrying on further research to bring about improvements in indigenous hoes commonly in use in the country.

Harvesters, Threshers and Winnowers

51.2.24 The proportion of the ripe crop that reaches the hands of the farmer ultimately after harvest depends on the efficiency of harvesting, threshing and winnowing. These operations are considered important not because they help in increasing the yield directly, but because if done properly they reduce harvesting losses and also improve the quality of the produce. Crops are harvested in different ways. Grain crops are cut by means of a sickle, cotton is picked by hands; groundnut crop is pulled out of ground by hand; and root crops; like potato are dug out with *kudali* by hand. There is no special indigenous implement for harvesting any crop. Sometimes blade harrow is used for harvesting groundnut; wooden plough is used for harvesting potato. An improved groundnut harvester was designed in the erstwhile Bombay State many years back, but this remained a museum piece. Imported type of potato digger is becom-

ing increasingly popular in potato growing regions of north. Barring these few improvements, no attempt has been made to bring about improvement in harvesting operations.

51.2.25 Threshing is the operation by which the marketable produce is separated from other parts of the plant. The operation is carried out in different ways. The common method is to use flail for separating grain by hand or by threshing under animal's feet. Threshing under bullocks' feet is the most common method followed all over the country. A simple stone roller has become quite common in jowar and ragi growing areas. It is interesting to note here that this implement was designed by a farmer in Ranebennur taluk in Karnataka as early as 1904. Wheat thresher consisting of a number of serrated discs has become popular in wheat growing areas. New pedal operated Japanese paddy threshers were received with great enthusiasm some years back, but these did not spread because of limited use for one crop only. This shows that further improvement is required to be carried out to make them acceptable in different regions. Maize sheller is another improved implement which is becoming quite popular in all the maize growing areas. Introduction of hand operated as well as machine operated shellers has considerably reduced drudgery of women workers in maize growing areas and has helped to complete the grain separating operation in a short period after harvest of crops.

51.2.26 The threshed material has to be winnowed for separating grain from chaff. Use of natural wind is the cheapest, but it is not very dependable. Sometimes days together are wasted just waiting for wind of suitable velocity. On some occasions, the produce is caught in untimely rains resulting in considerable losses and confusion. Winnowing fan operated by human labour was designed to obviate these difficulties. Box type winnower with enclosed fan was introduced. Both of them have not become as popular as they were expected to be when they were introduced. In recent years engine-operated stationary thresher-cum-winnowers are becoming popular especially in wheat growing areas. Stationary threshers capable of threshing all kinds of produce with simple adjustments are becoming available. Even combines which are capable of harvesting, threshing and winnowing all in one operation are being manufactured in the country. It was expected that they would be popular especially in wheat growing areas. Because of high costs they are not moving fast, resulting in locking up of the capital of the manufacturers.

51.2.27 Harvesting, threshing and winnowing are the three most labour consuming operations which are carried out mostly involving human labour, particularly female labour. The methods adopted at

present are inefficient resulting in considerable losses in the process. Attempts made to bring about improvement in the process have not succeeded so far. Just as the drudgery of grinding of cereals has been removed from village scene by establishing engine-driven flour mills, engine-driven stationary thresher-cum-winnower should be located in every village in required number to meet the full needs on custom service basis. This will remove the drudgery and reduce the losses that commonly occur in carrying out threshing and winnowing operations by traditional methods. Attempts should be made to devise simple reapers for havesting, also for the same reason. Suitable machines should be developed and used for harvesting crops like groundnut, cotton, potato etc., which also require considerable human labour and are subject to heavy harvesting losses at present.

Devices for Lifting Water

51.2.28 Two sources of irrigation are surface water and underground water. Sources of surface water are flowing rivers, *nalas*, streams or reservoirs and the tanks in which surface runoff is stored. Water from these sources is taken to fields by gravity. Sometimes water is required to be lifted from these sources to cover the high-lying areas not commanded by gravity flow. Underground water has also to be lifted and used for irrigation. Flow irrigation is cheap but not possible everywhere. Lift irrigation although costly has to be resorted to stabilise and increase production. Lifting of water is done in numerous ways. Ingenious and simple devices are in use all over the country. Small water lifts like irrigation spoon and Archemedian screw (Figure (h) of Appendix 51.3) are used to lift water through 60-150 cm height. Various kinds of counterpoise water lifts are in use all over the country. These lifts are used to take water through 3-5 metres height. While Persian wheels (Figure (i) of Appendix 51.3) are used where water is to be lifted through 6-10 metres height, leather or iron *mohts* are used even upto 18-25 metres heights. In recent years water lifting is mechanised to a very great extent with considerable advantage. We have suggested in Chapter 50 on Farm Power that water lifting should be completely mechanised and should be done preferably with electric motors. Even then, there will be occasions when only small quantity of water is available and lifting is to be done through a few feet only. In such cases, heavy investment on machine pumps may not be worthwhile. It is, therefore, necessary to continue research and develop simple bullock or hand operated devices which give increased mechanical advantage over the

existing indigenous types. Sustained and increased attention should be paid to this aspect of research in engineering field.

Miscellaneous Appliances and Hand Tools

51.2.29 The farm has to be equipped with not only field implements mentioned or discussed so far but also other appliances and hand tools. The miscellaneous appliances are numerous. Some of the common ones are seed drum sugarcane crusher and chaff cutter. Common hand tools are sickle, *khurpi*, pickaxe and spade.

51.2.30 Seeds are required to be treated before sowing with various kinds of chemicals against pests and diseases. The simplest device to treat seeds is the earthern pot into which seed and chemical are put together and shaken for some time until seeds get coated with the chemical. An improved simple contrivance is the seed drum made of wood or metal with an axle fitted with a crank handle passing through it. Seed to be treated is put in the drum along with chemical and the drum is given half round turns with handle. In future, seed production and distribution is likely to be a specialised job and may be handled by centralised organisations. Seed produced and distributed by such organisations is going to be pre-treated and the individual farmer is not likely to be required to treat the seed. Even then, locating one or two seed treating drums in every village may be advisable so that in case any special seed treatment is required it can be done in a scientific manner.

51.2.31 It is a happy situation to note that improved iron sugarcane crushers—bullock operated as well as machine operated—have almost replaced the old wooden crushers. Similarly, improved chaff cutters are becoming popular all over the country though their spread is not extensive. It is necessary to take special steps to popularise chaff cutters all over the country and see that every farmer possesses one of suitable size, so that wastage of fodder is considerably reduced.

51.2.32 *Khurpi*, sickle, axe, pickaxe and spade are the usual hand tools that are available practically with every agricultural worker. Some of the hand tools like rakes, plant puller, crow bar etc., are also available with some farmers. Hand tools are of different sizes and shapes according to specific purpose for which they are used, prevailing soil conditions, locally available materials and local customs. These hand tools are made generally by local artisans. They are also cheap and easy to repair. Majority of these hand tools are made of scrap metal. Local artisans seldom know how to temper metal to maintain the sharp edge. Tools become blunt and ineffective soon.

They are continued to be used as such without getting them shaped properly. Farmers use such ineffective tools which tire them out quickly. There is considerable scope for bringing about improvement in design and quality of metal used. Special attention is required to be paid to balance, manipulation and weight of these tools. Marked improvement in their design would mean effective utilisation of man's strength without causing him undue fatigue. We, therefore, recommend that intensive research should be carried out on all hand tools to bring about improvements in design and in quality of metal used so that they may be more effective under use.

51.2.33 Improved tools should become available locally at low price. Some of the important problems are standardisation, production and distribution. The steel of desired quality should be produced and made available at fair price to production centres through steel banks, which should be set up specially for the purpose. It should be possible to standardise the shapes of implements also. Manufacturing of such standard tools can be taken up at the taluk or district or even State level. This responsibility can be entrusted to the farmers' cooperatives specially set up for the purpose as has been done in some States or to agro-industries corporations. The local artisans should also be encouraged to take up manufacture of these tools, if trained adequately. These artisans should be trained more in repairs of these tools rather than in manufacturing. Workshop wings were established in some of the gram sevak training centres with the main objective of training local artisans and improving their professional ability to cope with changing demands of modern farming. These centres have not succeeded in achieving this objective and they are also not popular. They are not attracting the right type of candidates. Candidates come there mainly because they get stipends. After training they try to get some job or other in urban establishments instead of returning to their villages. These centres should be activised and many more such centres set up in order to train the local artisans in repairs of improved hand tools and other implements.

General Improvements

51.2.34 Farming operations in India will continue to be carried out with the aid of hand tools and bullock drawn implements. Energy spent in performing these operations is considerable. Quite a lot of it is wasted because of use of ineffective tools and implements. At the same time, work done is inefficient and involves considerable drudgery and fatigue both to human beings and animals. As a result, inspite

of hard work put in by farmer and his animals the returns are not commensurate. One of the reasons for obtaining low yield was that the farmer was often unable to carry out various operations in time and efficiently. Farmers in different regions are content with the tools and implements they have at present, because they have had no opportunity to know of better ones. Research efforts put in so far cannot be said to be sufficient. The team of specialists from Michigan State University in the USA, after carrying out detailed study on agricultural mechanisation in Equatorial Africa, has made the following recommendation for the improvement of tools and implements:—

> "The following are vital considerations in developing new tools and implements and improving those already in use: (1) adapt tools for more efficient performance and speedy work: (2) minimize fatigue by improved balance and working position; (3) reduce injury or wear to man or animal; (4) keep weight low for easy transport; (5) construct from local readily available materials; (6) choose the most simple design appropriate to the job; (7) design for specific tasks, and with only simple adjustments; (8) require the least maintenance and preparation for use; (9) construct so that parts can fit together only one way; (10) secure firm fastening between handle and blade; (11) eliminate wherever possible, the need for wrenches (spanners) or special tools for adjustment; (12) make simple tool clamps with no nuts or pieces to lose; (13) use self-locking pins chained to frame for joining parts; (14) design to accommodate high workloads caused by unusually dry or hard conditions (animal tool-bars should be capable of pulls up to 454 kg.); (15) give careful attention to improving drawbar hitches."

We fully endrose the views expressed by this team and recommend that the research workers in India too should keep these recommendations in view in carrying out improvements of tools and implements.

51.2.35 There is another important aspect that requires special consideration. One of the drawbacks of indigenous implements in the country is that every implement has its own body and beam in addition to working part. In some areas yokes are also different for different implements. The cost of beam and body could be reduced by providing adjustable body, which can take on any working part. In short, what is needed is a tool bar preferably mounted on wheels and a beam fixed to it for hitching to the yoke. Different working parts like plough, harrow, blade, drill or inter-cultivation implements could be fixed as required. An attempt was made by M/s Voltas to put on the market an Otto Frame, which is of the type mentioned

above. This frame was suitable to take a cart also. The contrivance did not become popular because of cost. In some foreign countries attempts are being made to devise such multi-purpose tool bars. The National Institute of Agricultural Engineering in Great Britain has designed an all-purpose animal drawn tool bar for African conditions. It can take various tillage, sowing and inter-cultivation implements and in addition a platform or box for hauling. The French designed Nolle Ariana which is a skid type multipurpose ox-drawn tool frame and the Polyculteur ox-drawn wheel type tool bar are other attempts in this direction.[1] Recently, a multipurpose tool bar has also been developed at the Agricultural College, Junagarh attached to the Gujarat Agricultural University. Excepting for the bullock cart, it can be worked with various kinds of implements as illustrated in the sketch given in Appendix 51.4. One firm has already undertaken to manufacture it. Its cost at present is around Rs. 900. Attempts like this are required to be intensified in India to develop a general multi-purpose tool bar which can be adopted all over the country, so that the cost of manufacture and supply could be reduced and the price fixed would be economical.

51.2.36 In general the objective should be to develop implements and machinery which will raise productivity, reduce drudgery and which can be worked with ease, speed and accuracy. In developing such implements, the help of local artisans should be invariably sought. Local talent can contribute a lot in making suggestions for developing better designs. There was a scheme a few years back by the ICAR for giving prizes to local artisans which was suspended. We recommend that the scheme be revived and wide publicity given to attract attention of local artisans to it. The task of developing improved implements and tools is a gigantic one and in this task the help of every artisan should be mobilised.

Bullock Carts

51.2.37 There were about 13 million bullock carts in the country according to the 1966 Livestock Census and these would have reached by now the 15 million mark. As we have visualised in Chapter 56 on Marketing, Transport and Storage these carts would continue to play a prominent role in the transport of agricultural commodities below the towns' level for a long time to come. They are still largely old fashioned and hence require to be improved. Two types have already

1. 1969. KLINE, C.K., *et. al.* Report on Agricultural Mechanisation in Equatorial Africa, Research Report No. 6,—Institute of International Agriculture, College of Agriculture and Natural Resources, Michigan State University.

been developed, one utilizing second-hand truck axles and tyres and the other Dunlop axles and pneumatic tyres. Such carts are increasingly seen in suburban and urban areas, but these have still to make their impact on villages. On research side, the two most important needs are: (a) to examine whether solid rubber tyres would not be better than the pneumatic ones, because the former would do away with the need for repairing punctures as most villages lack the facility for immediate attention to this, and (b) to standardize the sizes of the cart wheel of different regions to facilitate large scale manufacture and wide distribution of tyres of fixed sizes. On the practical side, the problem is that of manufacture. The manufacture of such a large number of carts will constitute a new activity of a colossal scale. Private entrepreneurs may not be able to come forward in large numbers to undertake the full magnitude of the task to begin with. This is a field of activity, which must be planned and implemented by the agro-industries corporations for the entire country. The Panel of Agricultural Implements has, however, opined that these corporations need not enter other fields of implement manufacture as this would mar the chances of small and medium scale manufacturers. We are also not in favour of these corporations assuming any competitive role with any established small or big industry. Our stand in this regard is that the agro-industries corporations should undertake the manufacture of such items which are not manufactured by others and in such areas where no alternative arrangement exists. This principle should be applied to the manufacture of farm implements and machinery also.

51.2.38 An important point insofar as bullocks are concerned relates to the yoke, which is a necessary contrivance for connecting the bullocks either to the implements and machinery or the bullock cart. The emphasis in future is for developing animals through cross breeding programmes. The hump structure of crossbred bullocks could be different from that of the indigenous ones. Because of this, the design of yokes to be used with such crossbred draught animals will also undergo change. This aspect has also to be kept in view in future researches.

3 INANIMATE POWER OPERATED IMPLEMENTS AND MACHINERY

51.3.1 In the field of mechanical and electrical power, it is the tractor which is most versatile in farming operations. All tillage operations can be performed through it. Although electrical power is harnessed for operating irrigation pumps and can also be used for

stationary jobs like threshing, tractor power can operate any machine—whether it is for pumping water or harvesting crops or threshing—and many of these machines can be operated equally well with mechanical or electrical power with slight modification. With the introduction of the tractor as mobile power, many kinds of implements and machinery have been introduced in the country, e.g., trailers, cultivators, disc harrow, mouldboard plough, disc plough, seed-cum-fertilizer drill, seeding attachment, planter with fertiliser attachement, levelling blade, dozer front, scraper, leveller, tractor mounted sprayers and dusters, tractor mounted liquid fertilizer applicator, fertilizer speeder, rotavator, spike tooth harrow, chisel plough, mower, clod crusher, wind rower, maize sheller, forage harvester, baler, chaff cutter, fodder mill feed grinder, groundnut digger, groundnut decorticator, potato harvester, potato planter, dryer, seed cleaner, thresher, mounted pumping set, loader and lifter, sugarcane planter, sugarcane harvester, blade harrow, farmer stroke picker, cotton picker, soyabean harvester etc. At present, what is most often purchased along with a tractor is a cultivator or disc harrow and a trailer. Next preference is to ploughs (mouldboard or disc plough), seed-cum-fertilizer drill or simple seeding attachments. The other machinery is much less in use. Much of the machinery used to be imported in the beginning, but with the beginning of manufacturing of tractors, the important matching implements and machinery are also manufactured in the country. However, it must be said that very little research is being carried out to develop designs that would suit the varying conditions in the country. The implements and machinery available in the country today are of the same type as were introduced from outside along with tractors. In other countries, considerable improvements have been made in the design and the steel material used for manufacture. It is not sufficient just to imitate a design available elsewhere. It is necessary to carry out intensive research to improve the designs to suit varying soil conditions in the country. It is not sufficient if work is carried out at one or two places in the country, since conditions differ from place to place considerably.

51.3.2 It is mentioned in one of the documents of the Planning Commission pertaining to the Fifth Five Year Plan[1] that manufacturing capacity will have to be organised for some specialised items like reapers, binders, tractor mounted and tractor drawn pull type combine harvesters, self-propelled combines, roto tillers and seed and fertiliser placing machines. It is stated therein that the intending manufacturers will have to be encouraged by way of import of sample machines

[1]. 1973. Report of the Working Group of the Task Force (1) on the Agricultural Machinery Industry; New Delhi, Planning Commission.

for trials, development, evaluation and ultimate adoption. It is stated in that document that there is need for the importation of prototypes also. A suggestion for import of machinery for developing prototypes is also contained in the report of the 1967 Panel on Agricultural Implements. We are not in favour of too much dependence on foreign machinery as a matter of routine. We must be able to develop an expertise which is capable of designing and fabricating machinery typical to the country's needs on its own initiative. Import of new material should be resorted to only in exceptional cases.

51.3.3 We have identified certain machinery, which have been listed below, with which a beginning could be made in the design and development work :

(i) seed bed preparation and land shaping: (a) land planes of suitable sizes for wheel tractors; (b) rotovators for rotary tillage for reducing time involved in seed bed preparation in multi-crop areas; (c) stalk shredders for maize, cotton etc.; (d) chisel ploughs and mulchers for dry farming areas; (e) attachments for low cost three speed garden tractors used by small farmers; and (f) half-track attachments etc., for utilisation of wheel tractors in land development work.

(ii) seeding and planting machinery: (a) semi-mounted seed-cum-fertiliser drill for higher output; (b) automatic potato planters with fertiliser attachments; (c) transplanters for paddy; (d) automatic sugarcane planters; (e) unit planters; (f) improved drills for multi-crops; (g) low cost seed drills; (h) weedicide, fungicide and insecticide attachments to seed drills; and (i) furrow openers of reduced power and placement for different soil and moisture conditions.

(iii) machinery for fertiliser application : (a) wide swath tractor-mounted or trailed fertiliser spreaders; (b) anhydrous ammonia applicator and fertiliser solution distributors; and (c) seed and fertiliser metering devices for use on seed drills and planters.

(iv) equipment for intercultivation : (a) row crop cultivators with full and half sweeps for weeding and hoeing the standing crop; (b) rotary cultivators for crops like groundnut; and (c) crop thinners.

(v) plant protection equipment : (a) high clearance self-propelled sprayers for various crops; (b) ultra-low volume sprayers with wind shields; and (c) electrostatically charged dusters.

(vi) harvesting equipment : (a) tractor-mounted binders for wheat, paddy etc.; (b) tractor operated combines; (c) vacuum pickers for cotton; (d) potato combines; (e) reapers for harvesting different crops; (f) rotary mowers for harvesting of fodder; (g) potato stem cutters; (h) forage harvesters for direct har-

vesting as well as for swath picking and chopping; (i) back mounted cutters; and (j) low horsepower harvesting machines.

(vii) threshing and processing equipment : (a) straw rack type threshers for wheat, paddy etc; (b) groundnut threshers; (c) high output groundnut decorticators; (d) universal wagon for handling of farm produce in bulk; (e) portable bucket and augur type conveyors; and (f) rotary screen seed cleaners for wheat paddy etc.

51.3.4 This opportunity could be utilized to systematise the entire research work on implements and machinery going on in the country starting from designing and ending with feasibility trials of the developed implements. The last step has got to be the responsibility of the institute which has developed a particular implement. It is only after such testing that the prototype should be handed over to the manufacturers for mass scale production. The institutions which have to be involved in this research work are : the Central Institute of Agricultural Engineering, Indian institutes of technology (IITs) and the agricultural universities. All these institutes must have enough workshop facilities. At present, RTTCs throughout the country do not have adequate workshop facilities for producing the prototypes nor do they have adequate funds for the purpose. Because of these difficulties they are neither in a position to manufacture prototypes by themselves nor test them properly. If they choose to get it done through manufacturers, their cooperation cannot be taken for granted, because the tendency of manufacturers is to get a ready design for manufacturing without undertaking any preproduction feasibility trials. In order to do away with this lacuna in a very vital field, it is imperative that all RTTCs dealing with implements and machinery must be provided with the necessary funds and facilities to produce prototypes independently. The number of prototypes for each implement and machine should not be less than 25. The rigidity of administrative rules may at times block the rapid progress of prototypes production. Therefore, there is need for relaxing rules and leaving some initiative with the RTTCs concerned for this purpose. During the evaluation and demonstration of the prototype in the field, research workers should themselves surpervise the trials and simultaneously obtain the farmers' viewpoints. In fact, when the prototypes are proposed to be tested, it will be ideal for research workers to associate extension workers and manufacturers also so that there is exchange of ideas from the point of view of manufacturing and promotional work. Manufacture on mass scale should not be allowed without such feasibility trials. Once a prototype has been released after the feasibility trials, there can be arrangements to charge some fee from the prospective

manufacturer for allowing him to produce it on a mass scale. The income thus accruing to the RTTC can offset the expenditure incurred on such work.

51.3.5 We are of the opinion that the regional research, testing and training centres (RTTCs) which deal with farm machinery and implements must be strengthened with more capital investment to enable them play a leading role in their allotted sphere of activities. The RTTCs, which have not been still merged with agricultural universities should be placed under the latter; this is necessary in order to ensure a uniform pattern throughout the country. However, the universities must ensure that their essential nature is not destroyed because of the merger and the funds allocated to them are expended exclusively on their activities.

4 MANUFACTURE, QUALITY CONTROL, SUPPLY AND SERVICE

51.4.1 It has already been pointed out that most of the existing tractor manufacturers are producing matching implements and machines which go with the tractor. Besides the largescale sector, all kinds of agricultural implements and machines are also produced in the medium and small scale sectors and these are responsible for as much as 80 per cent of the production at present. The total number of such manufacturing units is placed around 2000, out of which nearly 1,300 are small scale units. About 800 of the small scale units are to some extent organised, but the rest are very small and mostly scattered in rural areas. The Panel on Agricultural Implements (Ministry of Industrial Development) has dealt with some of their problems in detail in its report. It has, opined that nearly half of the capacity of small scale units, which produce the bulk of implements and machinery, remains unutilized at present and, therefore, there is no need to create new capacity. We agree that this could be so, for the present, but the picture may have to be reviewed after a few years. The Task Force (1) on the Agricultural Machinery Industry of the Planning Commission has indicated the requirements of tractor-drawn implements and machinery upto 1978-79 as assessed by the Ministry of Agriculture and Irrigation. The real capacity in the case of tractor-drawn implements and machinery depends upon the pace with which this prime-mover or similar other machines are accepted. In general, the tractor manufacturing factories take care to ensure that related implements, ancillaries etc., are produced in sufficient number by them or the small and medium sectors allied to them. The Board of Agricultural Machinery and Implements has as one of its functions to review the requirements and related manufacturing programmes

from time to time. In view of this situation, it is not necessary to estimate the number of various implements and machinery in an elaborate manner. Suffice it to say that the capacity in the existing small, medium and large scale sectors of industry will be sufficient to cope with the usual demand of implements and machinery. The difficulty of the manufacturers in respect of raw materials is also well understood by the administrators and planners. Hence it can be presumed that the situation will improve in due course. It should be clear that there is awareness about the requirements and the related needs of the manufacturing industry with regard to the various kinds of implements. What remains to be looked into is the quality of the implements and machines produced and their ready availability to farmers. It is also necessary to have adequate arrangements for their maintenance and repair at convenient location. The discussions which follow will centre around these requirements. It may be pointed out that training facilities for technicians and artisans can be easily met by the arrangements suggested for this purpose in Chapter 50 on Farm Power. Similarly, the same administrative set up which has been suggested in that chapter should be able to take care of the administrative and extension requirements relating to the topics discussed in this chapter. These aspects will not be discussed in the present chapter in order to avoid repetition.

Quality Control

51.4.2 The main problem with regard to implements and machinery from the farmers' point of view pertains to quality. What is produced by village blacksmiths and carpenters does not conform to any standard. These artisans have no idea of the ideal shape and size which can give better efficiency with the least use of force and contribute to reduce the tedium. The artisans in semi-urban towns, tehsil headquarters or sub-divisional headquarters are better equipped than the first category. They might have some equipment like welding sets drilling equipment or a lathe. They might be able to manufacture even items like small mouldboard ploughs, tillers, cultivators, levellers and paddy weeders, but the quality of the product would be doubtful. In the case of big manufacturers, who are in a position to produce quality product, there is often an exaggerated claim about the quality and performance. For example, while defining the performance of a thresher, usually the maximum output claimed is never attained, more so with the recommended power units. These problems could be overcome in the following manner :

(i) The ISI standards should be made applicable to all the manufacturers in any sector. The ISI has already standar-

dised about 90 implements[1]. They should try to cover all possible implements and machinery expeditiously.

(ii) The village artisans should be made familiar with the ISI standards relevant to their profession. The responsibility for testing their products should lie with the agro-industries corporations. This simple procedure is suggested in order to save them from harassment from any cumbersome procedure of testing and standardisation.

(iii) The testing of implements and tools manufactured by the medium and the large sector undertakings should be conducted by the RTTCs situated in different States. These centres should have a special cell for this purpose so that delays and resultant annoyance of the manufacturers can be avoided.

(iv) In the case of big manufacturers, it has to be insisted upon that each machine sold by them should have a performance report.

(v) There have to be some uniform standards for evaluation applicable throughout the country. In this connection, the Central Institute of Agricultural Engineering can take a lead in cooperation with all RTTCs.

51.4.3 There are manufacturers who are interested in adopting the ISI standards even now, but they are discouraged by strict and lengthy procedures of the ISI marking systems. The application fee prescribed is Rs. 100; another non-refundable fee of Rs. 100 is charged for preliminary inspection; the entire testing cost runs into a still bigger sum. After the grant of licence, an annual licence fee of Rs. 200 and a renewal fee of Rs. 50 are charged in addition to the marking fee which is related to the quantum of production. In some cases of standardisation, the materials prescribed are hardly available in local markets. The Panel on Agricultural Implements has already recommended that the ISI should reduce their fees for their certification marking scheme. It has also recommended that ISI should always indicate alternative materials wherever the performance of the implements remains unaltered despite the change in material. It has also recommended that the ISI should rationalise the size and specification of raw material and may allow a range of 'sections' for the use of manufacturers.

Need for Market Surveys and Demand Studies

51.4.4 If there is one field where information is altogether lacking, it is that of market intelligence. Big manufacturing concerns do make

. 1974. Report 1973-74—Department of Agriculture p. 41, New Delhi, Ministry of Agriculture.

their own estimates, but other manufacturers suffer totally from the lack of this information. Their production has no relationship with the demand factor; hence their meagre resources either get locked up by over production or they earn less profit because of low turnover. This lacuna should be removed by State Departments of Agriculture and arrangements must be made to keep the manufacturers posted with relevant information up to the lowest level.

Supply and Service

51.4.5 It is recognised that there is no satisfactory arrangement at present for the sale of implements and maintenance or repair service close to farmers fields. We have proposed in Chapter 50 on Farm Power that the agro-industries corporations should take up the responsibility of establishing full-fledged workshops at all taluk headquarters with a provision to provide forward bases of service in the interior, which could coincide with the proposed assembling and sub market centres, whose number would approximate to 30,000. With the coming up of these workshops, there would be no difficulty for repairs etc. These workshops themselves could be made the foci of supplying the essential implements and machines as well as spare parts. This arrangement under the agro-industries corporations would have the advantage of making available implements and machines to farmers up to the village level and ensuring supplies to them at reasonable rates. The involvement of the corporations in this activity is likely to introduce an element of competition in the market particularly among private dealers in implements and the latter will be restrained from charging exhorbitant prices. Besides their direct involvement, the agro-industries corporations should also encourage private parties to build up this business gradually up to the village level.

Employment Opportunities

51.4.6 As implements and machinery are rarely manufactured in isolation from tractors etc. by the large scale sector, their employment potential will be the same as indicated in Chapter 50 on Farm Power. Employment in the small scale sector essentially relates to the manufacturing of implements and tools. Marketing and servicing, if at all performed, are generally done by the same staff employed for production. There is a general opinion that the small scale sector may provide employment opportunities for 30 hands of various skills per unit on an average. This is corroborated by the following results of a study sponsored by the Commission:

average employment (number of men) per unit in the small scale sector

	design	pro-duction	market-ing	other jobs	total
managerial	..	0·9	0·1	..	1·0
qualified engineers	..	0·7	0·1	..	0·8
supervisory (technical)	0·2	1·2	..	..	1·4
skilled labour	0·5	24·5	..	..	25·0
semi-skilled labour	..	2·8	..	..	2·8
unskilled labour	..	1·6	..	..	1·6
others	..	1·0	..	..	1·0
total	0·7	32·7	0·2	..	33·6

For the existing 2,000 small scale industrial units, the present employment seems to be no less than 60.000. In addition, the proposed workshops might also employ a large number of skilled and semi-skilled manpower.

5 SUMMARY OF RECOMMENDATIONS

51.5.1 The main recommendations of this chapter are given below :

1. An exhaustive survey should be made to find out the causes for low acceptance of improved types of implements and machinery and the continued preference to wooden plough.

(Paragraphs 51.2.1 and 51.2.5)

2. Improvement of the wooden plough or its replacement with a mere acceptable form of the iron plough and the development of suitable types for different regions should receive due attention in research work. There should be a publicity drive to popularise the improved types.

(Paragraph 51.2.5)

3. Causes as to why a useful implement like blade harrow is not finding favour in northern alluvial tracts are to be assessed and attempts should be made to introduce it in the existing or modified form.

(Paragraph 51.2.7)

4. The use of levellers should be popularised both in rainfed as well as irrigated areas to make water management more efficient.

(Paragraph 51.2.10)

5. More attention is required to be paid to research on the entire system of land preparation in different regions of the country.

(Paragraph 51.2.12)

6. Extension work to promote improved land preparation implements and their right use is needed. Sale and service network to make these implements more easily available and a system of custom hire service at the village level are also required.

(Paragraph 51.2.13)

7. Appropriate types of seed drills should be introduced and local artisans trained to manufacture them and farmers to use them. Agricultural universities should intensify research in improving the drills. Suggestions from local artisans and farmers may be invited in this regard and some incentive rewards offered.

(Paragraph 51.2.18)

8. The new paddy transplanter developed in Orissa should be tried and improved further for adoption in all paddy growing areas.

(Paragraph 51.2.19)

9. The use of implements for inter-cultivation should be popularised along with drill sowing or dibbling. The indigenous hoes require improvement. The use of weedicides could also be encouraged to do away with the drudgery of hand operations.

(Paragraph 51.2.23)

10. Japanese model pedal operated thresher requires to be improved for general acceptance.

(Paragraph 51.2.25)

11. Every village should be provided with engine-driven stationary thresher-cum-winnower in required number on custom service basis. Attempts should also be made to devise simple reapers for harvesting various crops. Particular attention is required for developing harvesting machines for crops like groundnut, cotton and potato.

(Paragraph 51.2.27)

12. Efficient water lifting devices which are required to lift water through a few feet only (where use of engines is uneconomical) and which could be operated manually or through bullocks should be developed through research efforts.

(Paragraph 51.2.28)

13. One or two seed treating drums may be provided in every village. Chaffcutters need to be popularised so that each farmer has one.

(Paragraphs 51.2.30 and 51.2.31)

14. Intensive research on hand tools is required in respect to quality of metal and design so as to increase their effectiveness.

(Paragraph 51.2.32)

15. Improved tools of standardised shapes should be made available locally at low price. Steel of desired quality should be made available to production centres at fair price through special steel banks.

(Paragraph 51.2.33)

16. Manuafacture of standard tools can be taken up at the taluk or district or even State level through farmers' cooperatives or agro-industries corporations. Local artisans can also be trained adequately for this purpose though it is better they are trained more in repair work than in manufacturing. The gram sewak training centres should be activised and more centres set up to train local artisans in repair work.

(Paragraph 51.2.33)

17. In matters of improving or developing implements and machinery, some observations of the team of specialists of the Michigan State University applicable to mechanization of agriculture in Equatorial Africa and quoted in paragraph 51.2.34 of this report are relevant to Indian conditions also. Various authorities concerned with the improvement of agricultural implements should give their earnest attention to those observations and apply them to Indian conditions.

(Paragraph 51.2.34)

18. Design and development of a standard tool-bar for multipurpose use with various bullock drawn implements like plough, harrow, drill, inter-culture implements or even with cart is recommended.

(Paragraph 51.2.35)

19. Village artisans should be encouraged to give suggestions for developing better designs of tools and implements and suitable prizes should be given to them. The existence of this provision should be widely publicised.

(Paragraph 51.2.36)

20. The agro-industries corporations should undertake the manufacture of improved bullock carts. It should be examined whether solid rubber tyres would not be better than the pneumatic ones for use in bullock carts. The size of the cart wheel also requires to be standardised to facilitate large scale manufacture of tyres.

(Paragraph 51.2.37)

21. Future design of yokes should be such that they would suit the humps of improved crossbreed draught animals.

(Paragraph 51.2.38)

22. Import of implements and machinery for the development of prototypes should not be resorted to as a matter of routine and the emphasis should be to develop machines typical to the country's own conditions

(Paragraphs 51.3.2 and 51.3.3)

23. The development of prototypes of implements and machinery and their feasibility trials before release to the prospective manufacturers should be incorporated in the research programme compulsorily. The institutions which have to be made responsible for this kind of work are : the Central Institute of Agricultural Engineering, IITs and agricultural universities. Adequate workshop facilities should be created with every RTTC for this purpose and necessary funds provided.

(Paragraph 51.3.4)

24. When testing prototypes, research workers should associate farmers, extension workers as well as manufacturers in order to elicit their views on them.

(Paragraph 51.3.4)

25. RTTCs which deal with farm machinery and implements must be so strengthened as to enable them to play a prominent and leading role in their sphere of activities. All the RTTCs should be placed under one or the other agricultural universities. The universities must ensure that the individuality of RTTCs is not destoryed and their funds are expended on them only.

(Paragraph 51.3.5)

26. The ISI standards should be extended to all implements and machines manufactured in any sector—small, medium or big.

(Paragraph 51.4.2(i))

27. The testing of the implements made by village artisans should be done by agro-industries corporations, while those manufactured by the medium and large sectors should be done by the RTTCs. In the case of big manufacturers, each machine sold by them should have a performance report.

(Paragraphs 51.4.2(ii) to (iv))

28. Uniform standards for testing and evaluation of farm implements and machinery should be made applicable throughout the country.

(Paragraph 51.4.2(v))

29. The State Departments of Agriculture should undertake to collect data on market intelligence relating to agricultural implements and machinery. The information so collected should be disseminated amongst the manufacturers.

(Paragraph 51.4.4)

30. The workshops to be set up by agro-industries corporations for maintenance and repair service as suggested in Chapter 50 on Farm Power, should cater to the needs of farmers with regard to sales and service of implements and machines also. Besides this arrangement, the agro-industries corporations should also encourage private parties to undertake these services.

(Paragraph 51.4.5)

APPENDIX 51·2

(Paragraph 51·1·7)

Report of the Panel of Agricultural Implements

Office of the Development Commissioner (Small Scale Industries), Ministry of Industrial Development, Nirman Bhavan, New Delhi-11.

Terms of Reference and Recommendations.

Terms of Reference

1. To review from time to time the progress of the Agricultural Implements Industry, in the Small Sector particularly.

(a) to initiate a programme of estimation of capacity existing in the Small Scale Sector and recommend measures for the fuller utilisation thereof,

(b) to assess the present position of the Small Scale Sector of Agricultural Implements Industry and recommend possible lines of development,

(c) to recommend an integrated development programme for the industry in the Small Scale Sector vis-a-vist e large scale sector, suggesting specific share in the role for the small scale sector in the industry depending upon its potentialities and in the light of the overall requirements of the economy during the next 5, 10, 15 year periods,

(d) to suggest specific additional measures for the production of components parts, etc., required for the industry,

(e) to study the availability of raw materials for the industry with particular reference to supply from indigenous sources and suggest where necessary the share of the indigenous production to be reserved for the small scale sector and recommend measures for its proper distribution so as to enable the small scale units to obtain raw materials on equitable terms.

2. To recommend measures of assistance Technical, Financial, Marketing and Training and the Provision of facilities such as Research, Designing, Tool and Die making, Quality Control, Standardisation etc., for the rapid development, increase in productivity and fuller utilisation of capacity of the industry in the small scale sector.

3. To be in liaison with research organisations relating to the industry and from time to time recommend the adoption by the small scale sector of suitable new methods, processes, substitutes, etc., evolved in research laboratories and recommend to the research organisations the problems which would be taken up on a priority basis for the benefit of the small scale sector.

4. To consider the problems of the small scale enterprises in the industry and ecommend, from time to time, suitable policies, procedures, programmes, etc. for its development particularly in the rural and backward areas to the extent possible.

5. To explore the possibilities of and to recommend measures to facilitate the export of agricultural implements by the small scale sector.

6. To consider any other aspect relevant for the development of the industry in he small scale sector and suitable measures thereof.

Recommendations

(1) The existing units manufacturing agricultural implements are not utilising even up to 50 percent of their capacity.

(2) No further capacity should be created in manual and animal drawn agricultural implements industry.

(3) New capacity has to be created for more sophisticated and new agricultural implements and processing machinery.

(4) The State Director of Industries and Small Industries Service Institute may survey this industry.

(5) Large Scale units should obtain their requirements from ancillary small scale units and such condition may be imposed in the industrial licencing.

(6) Agro Industries Corporation should not be allowed to undertake the manufacture of Implements.

(7) Subsidy on agricultural implements should be dispensed with.

(8) Small Industries Development Corporation & Agro Industries Corporation should stock and supply the raw materials required by the agricultural implements industry at reasonable rates.

(9) The scarce raw material as well as high carbon steel sheets should be freely allowed to import by actual users.

(10) The assessment of raw materials for this industry should be undertaken by Small Industries Service Institute and Indian Agricultural Research Institute.

(11) In addition to village level workers demonstration should be provided with improved implements for demonstration purposes.

(12) Seed farms and other Government research farms should use only improved implements and latest techniques of farming and also conduct 3 to 4 yearly demonstrations.

(13) The farmers may be given a consolidated credit card basing on his total assets.

(14) The bank should also finance to purchase small value implesements.

(15) National Small Industries Corporation should charge 5% as earnest money instead of 20% for the units set up for agro service.

(16) Indian Standards Institution should decrease their fees for their certification marking scheme.

(17) Alternative material in the standard should be provided.

(18) Rationalisation in the sizes of the raw materials may be attempted by Indian Standards Institution.

(19) ISI marked implements should only be purchased by State Governments and other quasi Government institutions.

(20) Strong co-ordination between research institution ICAR and Ministry of Industrial Development should be established.

(21) An information and display centre for machinery and equipment used in the various foreign countries may be established.

(22) Improved implements from all over the world should be procured and encouragement given to local manufacturers for making prototypes.

(23) Firm equipment institute on the lines of USA should be established.

(24) A 'Buyers Guide' may be prepared with complete addresses of the manufacturers and product information.

(25) STC/Engineering Export Promotion Council may be approached for making a market survey in foreign countries.

(26) A consortium may be formed by the implement manufacturers for effecting export in a better way.

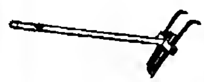
(27) Agricultural implements may be categorised in the schedule (one) and the rates of the drawback should be uniformly fixed.

(28) A study team may be sponsored for an on the spot study of the market in the Middle East and African countries.

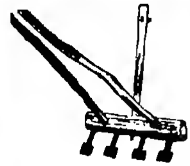
(29) A Regional Advisory Committee may be formed in the State level.

(30) Agro Servicing Centres with the technical personnel should be opened in the rural areas.

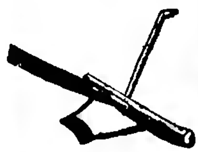
Twin Blade Harrow (Cuddapah) Andhra Pradesh



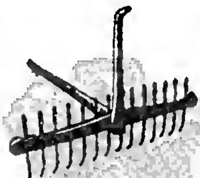
Harrow (Almora) Uttar Pradesh



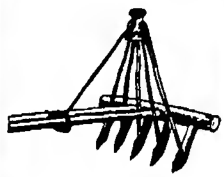
Tyned Hoe (Chingleput) Tamil Nadu



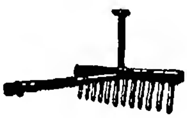
Blade Harrow (Guna) Madhya Pradesh



Harrow-Cum-Weeder (Nadia) West Bengal



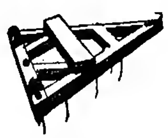
Five Tyned Drill (Amreli) Gujarat



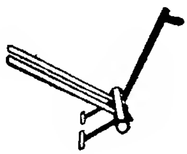
Harrow (Hassan) Karnataka

Blade Hoe (Dhulia) Maharashtra

Single Row Drill (Hoshangabad) Madhya Pradesh



Harrow - Punjab



Blade Hoe (Khargone) Madhya Pradesh

Appendix 51·1

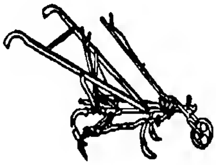
Certain Selected Indigenous Agricultural Implements

(Through Ages)

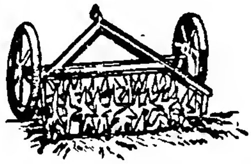
Source: I.C.A.R., 1960, Indigenous Agricultural Implements of India

DIAGRAMS OF CERTAIN SELECTED IMPLEMENTS

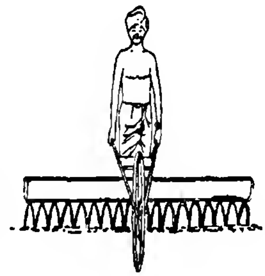
APPENDIX 51.3 (PARAGRAPHS 51.2.3, 51.2.7, 51.2.9, 51.2.15, 51.2.21, 51.2.28)



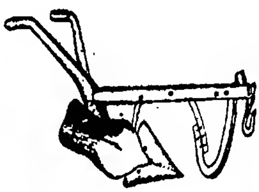
(a) SHOVEL TOOTH CULTIVATOR



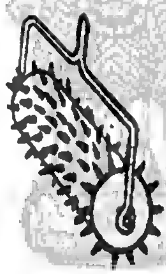
(d) NORWEGIAN HARROW



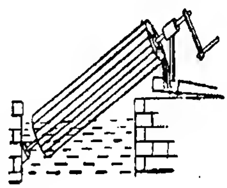
(g) WHEEL BARROW BROADCASTER



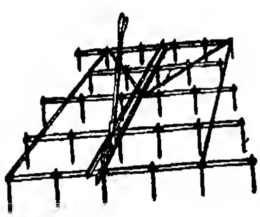
(b) TURNWREST PLOUGH



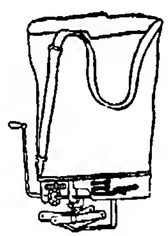
(e) ROLLER WITH SPIKES



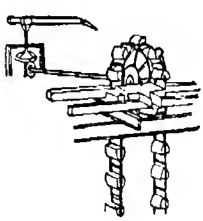
(h) ARCHEMEDIAN SCREW



(c) SPIKE TOOTH HARROW

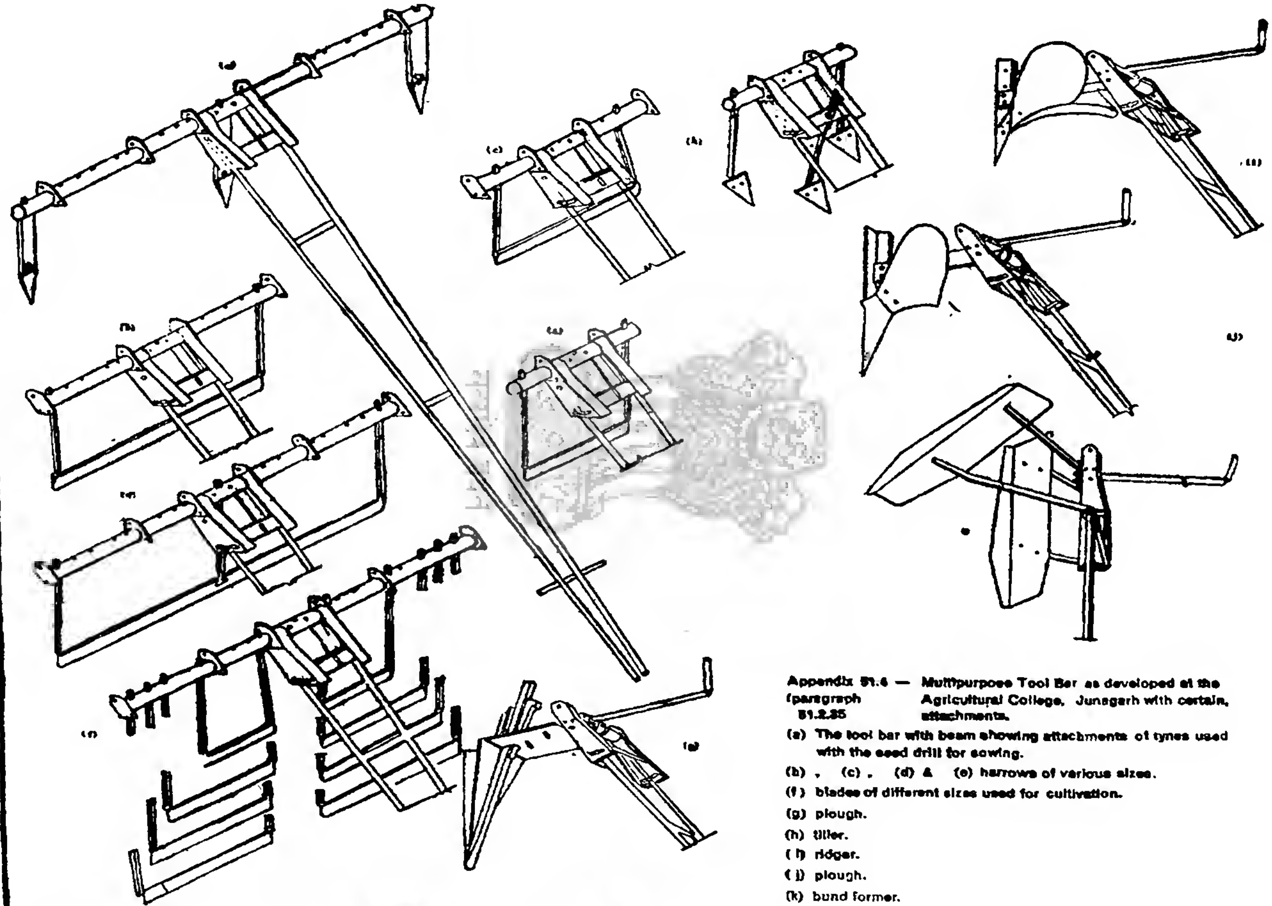


(f) KNAPSACK BROADCAST SEEDER



(i) PERSIAN WHEEL

सत्यमेव जयते



Appendix 51.4 — (paragraph 51.2.35) Multipurpose Tool Bar as developed at the Agricultural College, Junagarh with certain attachments.

(a) The tool bar with beam showing attachments of tynes used with the seed drill for sowing.

(b) , (c) , (d) & (e) harrows of various sizes.

(f) blades of different sizes used for cultivation.

(g) plough.

(h) tiller.

(i) ridger.

(j) plough.

(k) bund former.

GINP—S3—3 Deptt. of Agri/ND/76—16-12-76—5,000